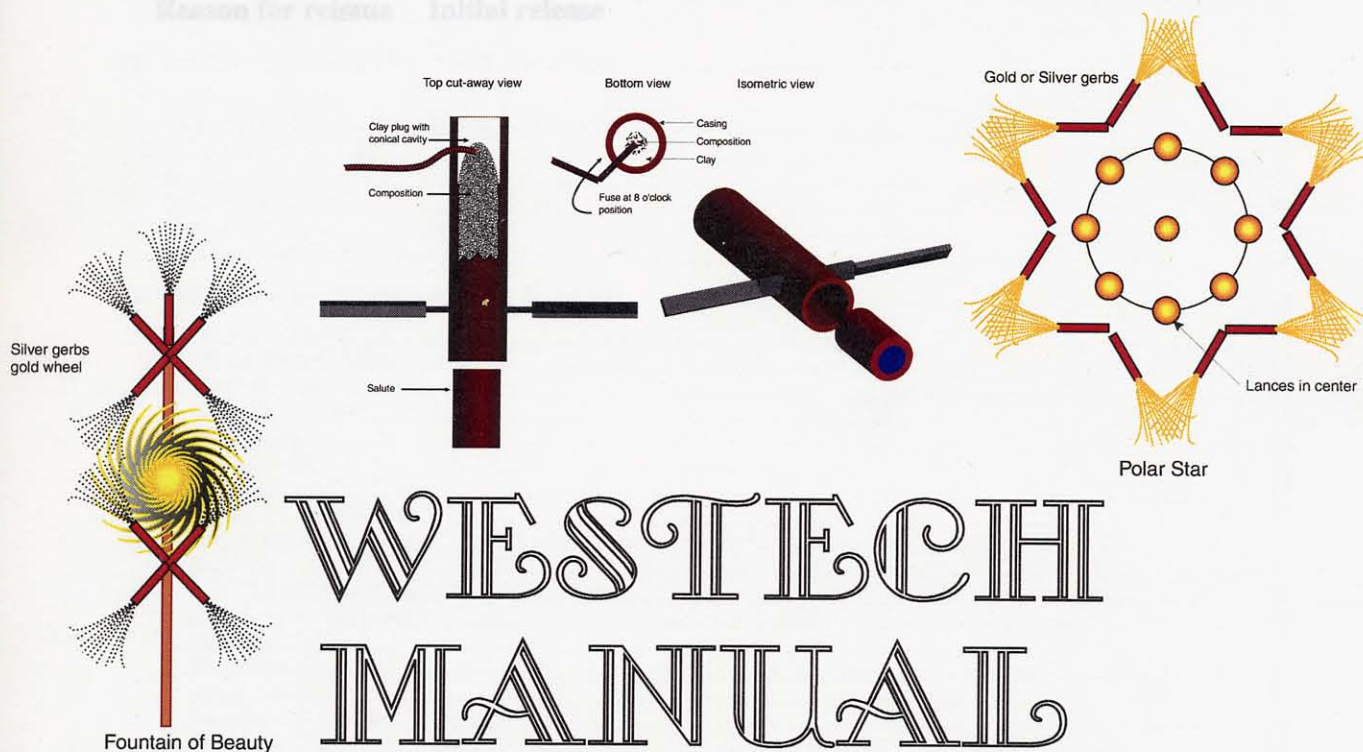
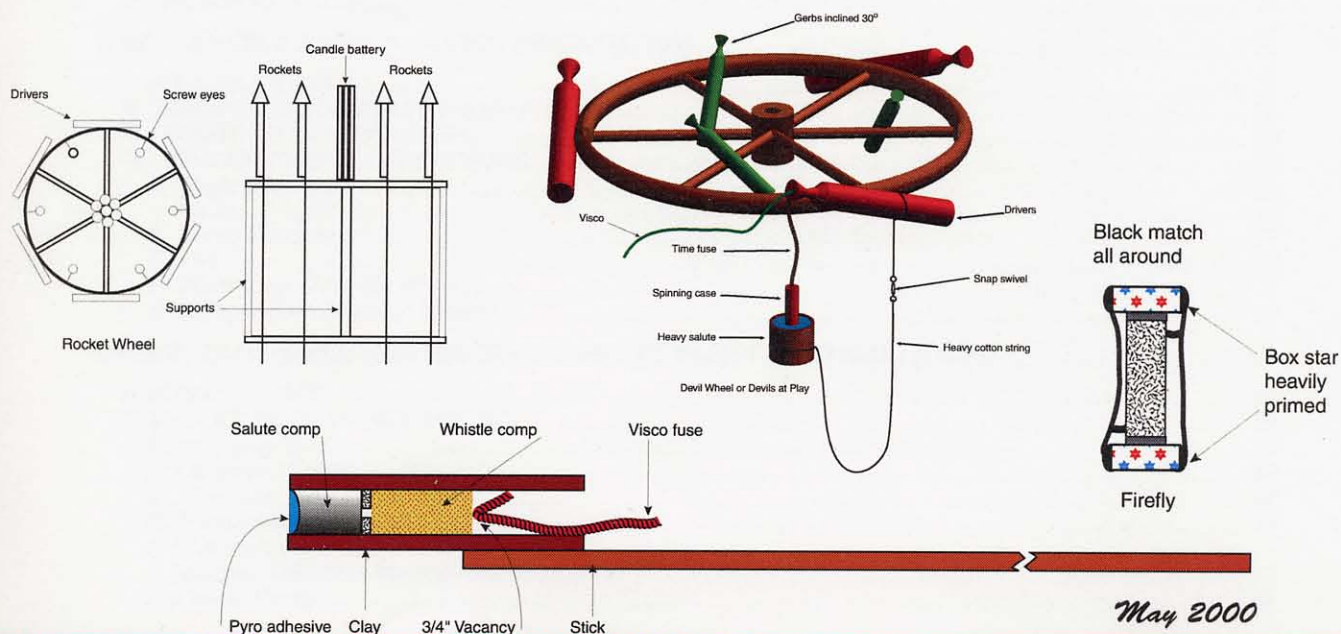


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BASIC PYROTECHNIC MANIPULATIONS (L-101)

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BASIC PYROTECHNIC MANIPULATIONS

I. INTRODUCTION

Pyrotechnics can be a very artistically satisfying and rewarding profession or hobby. But in order for pyrotechnics to be enjoyed in this manner, responsibility, knowledge, and imagination need to be exercised by the pyrotechnist. Pyrotechnics can also be extremely hazardous. Many tragic accidents are reported each year. However; in all cases, each one of these mishaps could have been avoided if simple safety precautions had been followed. Fireworks accidents happen to two classes: (1) to beginners who have insufficient skill or no knowledge of what they are doing; and (2) to the experienced, who after so many years of working with pyrotechnics, have become lax in following the safety precautions they already know. They knew better, yet they didn't. There is nothing easier than to make pyrotechnics dangerous, but, at the same time, it is not only possible, but very easy, to manufacture fireworks without danger. Therefore, all safety precautions given must be followed to the letter.

The staff of Westech has spared no pains in preparing this manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never been available before to the great majority of pyrotechnists. However, Westech will take no responsibility for any damage or injury resulting from use or misuse of this material, since the conditions of use are beyond our control. The purchaser and/or user take full responsibility for use. Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

All fireworks consist of three main parts: a composition (sometimes called "compo"), a casing, and a means of ignition. The composition formulas for the various items are given under the appropriate items in other treatises. The manufacture of the various types of casings generally used in all pyrotechnic devices are given here. Specifications peculiar to individual items are given elsewhere under the particular item. The common ignition mechanisms are described here. Pyrotechnic devices may also have other parts or factors used in their manufacture. Materials, items that neither make up part of the composition nor the casing but are necessary for their proper function, are described here. Any special tools required are given elsewhere under the particular item. General manipulations and procedures necessary to combine all the above in order to construct the various items are explained here. Specific manipulations and procedures are explained under the appropriate items.

II SAFETY PRECAUTIONS

1. If you are not 21 years of age, work with adult supervision.
2. Always wear adequate safety equipment when mixing or loading chemical mixtures. These operations are the most hazardous in pyrotechnics. Safety equipment should include: (1) a face shield or goggles; (2) fireproof gloves; (3) fireproof apron; (4) a dust respirator, when working with chemicals that are lightweight and finely powdered. These small particles gather in your lungs and stay there. They may cause serious injuries later in life. Especially dangerous are finely powdered aluminum and charcoal.
3. Make sure there are no open flames present when you are working. (Hot water heaters, furnaces, pilot lights in stoves, etc.) This includes smoking.
4. Always be neat. Keep area clean with no open chemical containers or spilled chemicals. When chemicals are spilled, immediately wash clean with water.
5. Keep chemicals and supplies in a safe, cool, dry place, out of reach of small children and pets.
6. Have a good source of water readily available. (Fire extinguisher, bucket of water, hose, etc.)
7. Always keep batches of any powder as small as practically possible. In case of accidental ignitions, small quantities are not extremely hazardous. NEVER mix more than a gram or two of flash or salute powder at one time.
8. When mixing ingredients, do it gently and carefully. If dust begins to rise during mixing, STOP! NEVER RUB, POUND, HAMMER, OR Grind TWO INGREDIENTS TOGETHER. ALWAYS GRIND CHEMICALS SEPARATELY, THEN MIX CAREFULLY TOGETHER USING MIXING SIEVES (except salute mixtures—these require special mixing.)
9. Wash hands and face well after working with chemicals. This includes ears and nose.

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BASIC PYROTECHNIC MANIPULATIONS

10. Never place any flammable mixture in a metal or glass casing. This includes CO2 cartridges and metal pipes. Use only paper casings such as those recommended in this manual.
11. Use a reliable variety of fuse. The 3/32" or 1/8" waterproof safety fuse available at Westech is ideal.
12. Do not set off fireworks where local laws prohibit such practice.
13. If a device fails to operate, leave it alone. After 1/2 hour examine it to discover the trouble and then bury it. Do not try to use or re-ignite it again. Never cut open the casing or try to unload it.
14. Do not mix chemicals indiscriminately. If you aren't absolutely sure of what you are doing or compounding, stop!
15. Avoid use of chlorates when at all possible. They are the chief hazard of even professionals, not to mention amateurs. Substitute a perchlorate or nitrate whenever possible. Chlorates form highly heat, shock, and friction sensitive mixtures and a careless mistake while handling them is disastrous. Never grind a chlorate with sulfur or any sulfur containing compound (sulfides, sulfates, etc.)

III. CASINGS

The various types of paper used to make casings are the following:

Kraft: This is the kind from which brown paper sacks are made. It may also be purchased in rolls or sheets in different weights. Any weight will do.

Chipboard: This is a rather thick type of paper. In addition to being used for rolling used for rolling mortar tubes. In the case of mortar tubes, mailing tubes or other strong paper tubes will give good results. Chipboard can be obtained from print shops, although it is quite expensive, in .015 to .022 thicknesses. It must be thoroughly soaked with paste before being wet-rolled.

All casings should be rolled so the grain of the paper goes up and down the length of the completed casing. The paper is cut against its grain and to the width of the desired length of the casing. Casings can be rolled in two different ways, wet, or dry.

A wet-rolled casing is made by applying a light coat of paste to the entire sheet of paper so it tears while rolling. A layer of paste is also applied to the former before the case is rolled to keep it from adhering to the former when it is withdrawn. Before withdrawing the former, the newly formed case is now firmly rolled and pressed back and forth on a smooth table top using a "rolling board." This action serves to drive out any air pockets and further squeeze the paper layers together to give the case a good tight construction. A quick and slight twist is now given to the former in the opposite direction to which the case was rolled around it so it may be easily withdrawn. Allow two days for a wet-rolled casing to dry. It should be dried in a warm, not hot, dry place. Room temperature is fine. A hot place will warp the tube in drying and thus give a weak construction.

A dry rolled casing is made by rolling the paper around the former and then applying paste only to the last edge of paper to keep the tube from unrolling.

Although some pyrotechnists use a "hot water" paste, a "cold water" type is preferred since it is easier to make and to apply. The best pyrotechnic quality paste can be made by adding 4 ounces of any type of flour to 3 cups of cold water, a little at a time and with constant stirring. When thoroughly mixed, add about 1.5 tablespoons of sodium silicate (thick, syrupy type) and mix thoroughly. The silicate allows the paste to completely penetrate into the fibers of the paper on which it is spread, thus producing more efficient bonding than ordinary paste. A brush called a "sash tool" is best for spreading the paste on the paper.

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BASIC PYROTECHNIC MANIPULATIONS

IV. IGNITION DEVICES

1. **Priming** - In order to insure ignition of certain articles, priming is used. It is made from either of the following compositions:

Table L-101-1 Priming compositions

Material	Parts by weight	
Meal Powder	11	
Potassium Nitrate		15
Charcoal, dust		3
Dextrin, yellow	1	1
Sulfur		2
Water	ad lib	ad lib

The most effective and by far the least expensive way to prime a device is to coat the priming on tissue paper. Add enough water to make a fairly thin priming, coat the tissue thoroughly, position it where needed, and allow to dry. The more surface area of the tissue that is exposed, the better. This method greatly conserves on priming and provides much more surface area for ignition, than the old way of dabbing on the priming as a thick paste.

2. **Match.** - There are two varieties of match: raw and quick.

A. Raw Match - This is made by coating thick about 1/8" cotton string with priming, or by coating many small strands and then joining them together. This latter method is by far the better one, since it gives a match that burns much fiercer because the priming is coated on the outside and the inside of the finished match.

The quickest, cleanness and best way is to use a Black Match Machine (T-MM). Another way (though it is quite messy) is to first place the string for about five minutes in boiling Water. This is to remove any of the moisture resistant coating that some varieties of string have. the "match cotton" (S-MC) available at Westech is ideal. It is especially made for making match and does not have the moisture resistant coating. It is also the ideal diameter and makes the "multi-strand" match.) Then, while it is still wet, tie one end to a nail that is placed about waist high and run the string to another similarly placed nail about 30 feet away. Do this with as many lengths of string as needed. With the right hand take a handful of priming which has had enough water added to it to make it about the consistency of very thin mud.

Only practice will tell how much water to add. It should not be so thin that it runs easily out of the hand. Nor should it be so thick that it goes on unevenly or too heavily on the string. Hold the pan of thinned priming in the left hand to catch any drippings and walk backward to the other end of the string, letting it run through the priming in the right hand. Do not be afraid of taking a good handful of priming; there is no clean way of making match rapidly. Water will have to be added from time to time to the priming to keep it thin enough, as the string soaks much of it from the priming. This is the reason for having the string as wet as possible before the priming is applied.

If the weather is dry, the match will be ready for piping in a day or two. When the match is dry and stiff, it may be cut and pipes threaded on.

B. Quick Match - This is made by simply enclosing raw match in a paper tube called a "Pipe". Match piping serves the double purpose of protecting the match as well as making it burn faster. A piece 20 feet long will flash from one end to the other in less than a second. A match pipe is made by dry rolling 3 or 4 turns of paper (Kraft, Manila or Newspaper) around a dowel 1/4" in diameter. The longer the pipe is made, the harder it is to roll. However, try to roll about three foot lengths. It is easier if the pipe is rolled at a slight spiral. Whenever two pipes must be joined, crease or gather the end of the first pipe so the next pipe may be slipped over it for about an inch.

3. **Safety Fuse** - This comes in various diameters from 3/32" to 3/8". It is waterproof, inexpensive, and the best fuse for fireworks ignition.

V. MATERIALS

1. **Adhesive** - This is Professional Pyrotechnic Adhesive. Complete details, formula and instructions for making it are available from Westech (Catalog number L-TR1.)

2. **Gunpowder** - This is standard black rifle powder. It can be obtained at sporting goods stores in one pound cans in grain sizes from the largest of Fg to the smallest of FFFFg. The Fg is preferable as a driving charge, the FFFFg for a bursting charge. The pyrotechnist cannot make normal gunpowder that has the driving ability of

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commercial black powder. Special presses, and heavy equipment weighing many tons are required. However, L-TR4 gives formulas and instructions for making excellent substitutes that are as good as, or better (and less expensive) than commercial black powder.

3. Meal Powder - This is standard black rifle powder ground with a mortar and pestle until it is in dust form. The FFFg is preferable because it is the smallest size grain. However, Fg, FFg, of FFFg may be used. They will just require more grinding. It is used in priming, match, bursting charges, composition formulas, etc. A fairly good substitute for meal powder can be made by the pyrotechnist using the following method. Refer to table L-101-2.

Table L-101-2 Meal powder composition

Material	Parts by weight
Potassium Nitrate	15
Sulfur	2
Charcoal dust	3

The Potassium Nitrate should be as pure and finely powdered as possible. The double, refined powder is ideal. Charcoal should also be very fine, and made from willow or other soft wood. "Air-floated, willow" is the best.

Make sure that each ingredient is in a very finely powdered form. This is especially necessary for the Potassium Nitrate. It should be as flour or powdered sugar. Mix all together and place in a tumbler, similar to those used in lapidary for polishing gems. Those available at Westech are ideal. Add lead balls (about 1/2" diameter and weighing twice the weight of the ingredients). Tumble for at least one hour. The longer it is tumbled, the stronger the powder will be. Care must be taken to do this away from any open flames, or sparks. The engine housing of the tumbler motor must be enclosed. The entire production should be conducted away from any property or people.

VI. TOOLS

These are the special tools that are necessary to make the fireworks described. Such things as formers, rammers, star pumps, ramming bases are included. It is understood that everyday tools such as scissors, saw, drill, drafting compass, etc. should also be on hand.

VII. MANIPULATION AND PROCEDURE

This is the manipulation of the compositions, casings, ignition devices, materials and tools, using a given procedure for the construction of the various fireworks items. The mere possession of a formula is of little use to one not acquainted with the proper manipulation of the ingredients and materials. Thus, the manipulation of compositions, casings, materials, and tools is more important than knowing how much of each to use.

A. Nosing - One of the basic manipulations for all fireworks that are primed is called "nosing". This is done by simply wrapping the filled and primed casing with a few turns of paper (decorative or plain). The paper should extend over each end about 1-1/2". These ends are called "nosings" and serve to protect the article from any premature ignition and also to secure the match in its place. The nosing may either be twisted or tied around the match, and tucked in the other end.

B. Mixing - Mixing is the most important manipulation in pyrotechnics. Without careful mixing, consistent and quality work is impossible to obtain. A properly mixed composition should be homogeneous and all ingredients of a predetermined and consistent particle size. This is where most amateurs go astray, their compositions lacking one or both of these qualities. Chemicals should be reduced to the necessary powdered form with a mortar and pestle and then weighed accurately on a good balance. The ingredients should then be mixed using mixing sieves because these insure not only a homogeneous mixture but help insure correct particle size and the whole process of mixing is greatly expedited and facilitated.

For general mixing operations, 24 mesh sieves should be used. All oxidizers should first be sifted through 40 mesh sieves. Then they are mixed with the ingredients, using 24 mesh sieves. Separate sieves must be used for mixing chlorate containing compositions, and those that do not contain any chlorates. The mixing sieve should be placed over a large sheet of paper and then all the ingredients passed through, one at a time. When all the mixture has passed through; mix again as before, sifting onto the first sheet of paper and giving a last thorough mixing. Never mix any salute composition using a mixing sieve. These ingredients should merely be lightly but thoroughly mixed on a piece of paper, using a plastic spoon.

When using metal filings, titanium, aluminum flitters, coarse charcoal, etc., these are saved until everything is sifted and mixed completely and then added and mixed into the composition.

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NOTE: Iron and steel filings should always be coated with paraffin or linseed oil to protect them from premature oxidation (usually by the saltpeter) if the device is to be stored for more than a day or two. If this is not done, the effect will be completely ruined, and the device useless.

C. Safety

1. Always add the saltpeter in the composition to the sulfur when sifting these two for the first time. Sometimes the sulfur is charged with static electricity so that it is very difficult to sift unless the saltpeter is added.
2. Never throw a chlorate onto the sieve with dextrin or other hydrocarbons. Sift the chlorate first and then add the other ingredients one by one.
3. Great care should be taken never to let the fingernails strike the sieve while working, as it is very easy to "strike fire" in this way, with disastrous effects.

D. Charging

A very important manipulation in pyrotechnics, and one which many newcomers have difficulty in doing properly is charging the various casings with composition. There are numerous ways to charge (fill) a case. The simplest is to merely pour the composition into the casing, as is done when filling salutes. Perhaps the most common is to drive (ram) composition into a casing. This is done by pouring small portions of composition into the case, inserting a rammer that securely fits into the opening, and then striking the rammer several blows with a mallet (preferably rawhide) so it firmly consolidates the composition. Rockets, fountains, wheel drivers and others are charged this way. The composition for these devices should only rise about 1/2" to 1" I.D. (after consolidation) for each charge composition. The use of measuring scoops, made especially for this purpose and available from Westech, is highly recommend.

Instead of using a mallet, the compo can also be consolidated using an arbor press. All ramming and pressing operations should be carried out on a very solid foundation.

A "ramming block," made in the following way, is ideal. Place a 2' length of solid timber (a 5 x 5" piece or thicker) in a 5-gallon pail. Now pour sand and/or small gravel around the timber. Rap the sides of the pail frequently so the filling is well consolidated. A cavity of some sort should be made in the middle and on the top of the timber to receive the ramming bases of the various tools. If these bases are all made the same size, then can be interchanged in the block. A 2" diameter x 1" deep cavity works well. (All tools at Westech are interchangeable in this size cavity.)

Pressing is done by inserting the rammer and then pressing the composition with hand pressure inside the case. This type of charging is used for filling whistles, box stars and other items. Another way of charging a case by ramming (driving) is with a funnel and rod instead of hammer and mallet. This is used to fill lances, bottle rockets and other small items. These operations are explained in more detail under the appropriate items.

VIII. CONCLUSION

In describing some of the manipulations and procedures on various items, exact dimensions and other specific details are not always given, but rather a general outline or idea. This is because these items are so dependent upon the experience and skill of the artificer and so dependent upon the particular raw materials, working conditions, etc., that what would prove satisfactory for one pyrotechnist would fail for ten others.

All formulas, manipulations, procedures, etc., should always be considered good advice, and not the irrevocable truth. Even the same formula will vary from time to time for the same individual. This is why pyrotechnics is an art requiring considerable experience and imagination and is, therefore, very rewarding only to those whose desire is sufficient to acquire them.

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EXPLODING FIREWORKS PART I (L-102A)

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EXPLODING FIREWORKS (PART I)

I. INTRODUCTION

Explosive sound has a legitimate place in fireworks but only if used with responsibility. Fireworks that explode with a snap, tremendous report, or anywhere in between are very exciting. However, they are also very dangerous to shoot and even more so to make. Many individuals have been seriously injured trying to make or use these items. All of these accidents could have been avoided if the individuals involved had had an adequate knowledge of the principles, theory, and safety precautions pertaining to these items. Thus, all safety precautions given in this treatise must be followed to the letter.

Certain principles of pyrotechnic theory are given so the pyrotechnist can better understand the processes that are involved in making exploding fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, viz. a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition, casing, nor ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulations and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility for use.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

Table L-102A-1 Composition formulas

Ingredient	Formula #1	Formula #2
Potassium Nitrate	5	
Aluminum, dark	2	3
Sulfur, flowers	3	
Potassium perchlorate		7

Note: All parts by weight. The oxidizers must be very finely powdered for maximum results. Necessary tools for compounding these formulas are a good lab scale and a mortar and pestle.

The success of these formulas depend on a good dark pyro aluminum. In the past, most of the salute and flash formulas combined potassium chlorate or potassium perchlorate with sulfur and or antimony sulfide, in addition to the aluminum.

These admixtures are extremely hazardous, and must never be used. They are very heat, shock, and friction sensitive. Thus, they may ignite by the mere process of mixing their ingredients, or by pouring the mixture into a case.

Besides this danger, some acid is always present in the sulfur or antimony sulfide. This acid attacks the chlorate, breaking it down into chloric acid which can cause the mixture to detonate without warning! Flowers of sulfur has much more acid content than sulfur flour, must never be used with oxidizers except the nitrates. The hazards of acid formation with the nitrates is not significant. However, the use of flowers of sulfur with perchlorates or chlorates is disastrous.

Thus, avoid the use of all chlorates whenever possible. never grind or rub a chlorate with any other chemical. This mixture can detonate without warning! Nearly 100% of accidents and mishaps attributable to fireworks making can be traced to the use of chlorate/sulfur or perchlorate sulfur mixtures.

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The use of these hazardous mixtures started many years ago when there was not available a good grade of dark pyro aluminum. To overcome this defect, and in order to obtain a good report, it was necessary to resort to chlorate/sulfur (and/or sulfide) or perchlorate/sulfur admixtures. These hazardous and old-fashioned formulas are perpetuated even today by those who aren't aware of the improved, modern dark pyro aluminum now available. This variety makes completely unnecessary the need for sulfur and sulfides in salute formulas. There are many varieties of aluminum powder, and there are many varieties of "dark pyro" aluminum. However, of all these types, only a few varieties of the "dark pyro" can be used. The majority give unsatisfactory performance. Therefore, if your results are not up to par, the fault is most likely with the type of aluminum used. The best advice is to be wary of the many varieties of aluminium and so-called "dark pyro" aluminum that are available today. Generally, the darker the aluminum, the more reactive it is. Even more depends upon its particle size and shape, and amount of grease, stearates, or other contaminants that decrease its reactivity. Unfortunately, most "dark" aluminium encountered are various shades of a greyish silver, instead of being really dark. They also are not of ideal particle size, and shape, and have too much grease content. After conducting hundreds of experiments on all the existent "dark pyro" aluminium Westech selected the best available. Its use is encouraged for quality

II. FIRECRACKERS ~ FLASHCRACKERS

A. Lady Finger

Both the black powder and flash type of Lady Fingers are made the same way. The only difference is in the type of exploding composition.

Composition: Formula 1, or meal powder.

Casings: All casings can be made from regular newspaper, which is the type of paper used in almost all firecrackers nowadays. They are 3/4" long x 1/8" O.D. x as small as possible I.D.

Ignition Device: Chinese type fuse see L-TR5 for complete details for making this item.

Tools: The only tool necessary is a very small nail.

Manipulation & Procedure: Cut the paper into 3/4" x 2" pieces. Fold 1/2" from one end. Sprinkle some composition along this fold and place a length of fuse so it protrudes from one end into the powder train. Now fold the smaller end of the paper over the powder and fuse and roll up tightly, pasting the last roll. Crimp the ends closed with the nail. These may also be made by the mass production process described below. Allowance should be made in the tool dimensions.

B. Common sized

These are crackers 1-3/4" in length or smaller and not exceeding 5/16" in O.D. Firecrackers not exceeding these dimensions formerly carried an import duty of only few cents pound. For large crackers the duty was such that it prohibited their importation. Their size designation became known as "common-sized."

Composition: Formula 1.

Casings: The common sized firecrackers are usual in the following sizes:

Table L-102A-2 Common size firecracker dimensions

Length	I.D.	O.D.
1"	1/8"	3/16"
1-1/2"	1/8"	3/16"
1-5/8"	1/8"	3/16"
1-11/16"	1/8"	5/16"
1-3/4"	1/8"	5/16"

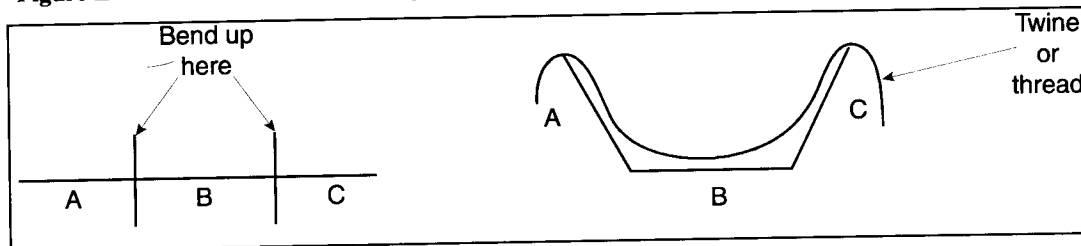
Ignition Device: Chinese-type fuse, or 3/32" safety fuse.

Tools: A nail for crimping the ends of the casings closed; a 1/8" x 3" case former (wooden dowel or metal rod) and a special firecracker tray made as follows:

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Cut a piece of metal, approx. .025" thick, 3" x 9". Divide it into 3 equal squares, each 3" on a side. Now, bend the two outside pieces up and toward each other, so the configuration shown in figure L-102A-1 is obtained.

Figure L-102A-1 Firecracker forming tool



Manipulation and Procedure: Dry-roll a piece of newspaper around the former. The newspaper should be 2' wide and whatever length will give a casing 3/16" (or 5/16") O.D. The desired length and number of casings are now cut from this long piece. A piece of strong twine, or thread (depending on the size of the casings), is draped over the cracker tray, so it lies as flush as possible against the sides and bottom of the tray.

Now stack the cracker casings so the twine goes under the exact center of the bottom row of casings. Pull and tie the loose ends of the twine together so the casings are formed into a tight bundle. Remove the bundle from the tray, stand it on end on a firm surface and crimp the ends of the casings closed with the nail by striking it a sharp blow against the inner rolls of paper at the ends of the tubes.

Turn the bundle over and paste a sheet of Gampi tissue over the open side of the handle, closing the ends which will later carry the fuses. When this is dry, holes corresponding to the tubes are punched in the paper. This is done by using one to four nails held in the hand while holding the bundle of tubes steady with the other. The edges of the paper are then bent slightly upward, giving it the form of a shallow saucer with many small holes in its bottom. The powder for charging the crackers is then introduced into this saucer, and the whole is shaken gently until all the tubes are full. Then, with a quick movement, flip the bundle in a complete revolution, so that the excess powder in the saucer, and a portion of the powder in each of the tubes, is emptied out, each of the tubes being left partly full of powder with enough space at the top for the fuse and the crimp.

The paper is now torn off from the bundle, and the fuses, cut to length, are put in place. After all fuses are in place, the final crimp is made as before.

C. Salute-sized

These are firecrackers 2" and 3" in length. There are two types: Chinese and American. The difference is in the type of fuse used and type of casing. The Chinese type use the Chinese type fuse and the newspaper casing just as in the smaller sizes of crackers. The American type use safety fuse and a wet-rolled casing of better quality paper such as Kraft or Manila.

Composition: Formula #1

Casings: (a) Chinese- Same as common-sized except the dimensions are: 2", or 3"x3/16" I.D. x 7/16" O.D. (b) American- Kraft, Manila or other good quality paper cut to the same length. Both kinds of casings are cut from 2' or 3' long tubes.

Ignition Device: Chinese type fuse (doubled) for the Chinese variety; 3/32" safety fuse for the American type.

Tools: A nail, a case former 3' long and 3/16" diameter.

Manipulation & Procedure: These may be made by the mass production process described above or they may be made singly as was described for Lady Fingers. If this is the case, the paper should be folded 2 or 3 inches from one end to make the fold.

D. Cannon Crackers

Composition: Formula 1.

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Casings: These are made from the same paper as the American salutes mentioned above and wet rolled in the following sizes:

Table L-102A-3 Standard cannon cracker dimensions

Length	I.D.	O.D.
4"	7/16"	9/16"
5"	1/2"	3/4"
6-1/2"	5/8"	7/8"
8	3/4"	1"
9-1/2"	7/8"	1-1/4"
10-1/2"	1"	1-1/2"
13"	1-1/4"	1-3/4"

Ignition Device: Chinese type fuse, or 3/32" safety fuse.

Materials: Professional Pyrotechic Adhesive

Tools: A nail, case formers in the above I.D. dimensions and 1/2" longer.

Manipulation & Procedure: After the cases have been rolled, and before they dry, crimp one end completely closed, and the other with an opening of about 1/4". Allow at least 2-3 days to dry. Fill about 3/4 full with composition (a fuller load will give a decreased report), and insert a length of safety fuse. Now plug both ends with a thick mixture of Professional Pyrotechic Adhesive and let dry.

III. SALUTES

A. Silver Tube Salutes

Composition: Formula #2

Casings: These can be brought ready made from Westech or can be rolled by the pyrotechnist. Use good quality paper (Kraft or Manila). Also necessary are a pair of end plugs. These cannot be easily made but can be obtained from Westech. Note: End plugs are not necessary if you plug the casings by the "Acceloseal" method (L-TR7).

Ignition Device: 3/32" or 1/8" safety fuse.

Materials: Pro. Pyro Adhesive.

Tools: A former 1/2" in diameter and 3" long.

Manipulation and Procedure: cut the paper into 36" x 24" pieces and wet-roll making a tube 36" long when dry. Punch a hole in the middle of the wall of the casing and insert a length of safety fuse. Apply some Professional Pyro Adhesive to a paper end plug with a brush and insert the plug into an end of the casing. Allow to dry for a few minutes. Fill about 3/4 full with powder and secure the other end plug with the adhesive. Do not allow the powder to come in contact with the wet adhesive. Allow the salute to stand on its dry end until the last plug and adhesive are dry.

B. M-80 Salutes

These are exactly like the above except using a 9/16" diameter case former and a 36" x 28" length of paper.

C. Cherry Bombs

Composition: Formula #2

Casings: These are two paper cups, one fits inside the other to form a complete casing. This is then dipped in a modified mixture of Pro. Pyro Adhesive. These casings can be obtained from Westech, since they cannot be made by the pyrotechnist. They are made in large factories using mechanical pinches.

Ignition Device: 3/32" or 1/8" green safety fuse.

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Materials: Pro. Pyro Adhesive modified for making Cherry Bombs.

Manipulation and Procedure: Punch a small hole in the inner cup. Insert a length of green fuse. Fill the inner cup about 3/4 full of powder. Fit the two cups together. Hold the Cherry Bomb by the fuse and dip it into the modified Adhesive.

D. Super Bull Dog Salutes

Different items go by this same name. Essentially they are all barrel-shaped salutes with a center fuse. Some manufacturers use a standard M-80 type casing without "M-80" written on it and call this a Bull Dog salute. Others merely use a red casing the size of a silver salute. But the best known variety is essentially an enlarged Cherry Bomb. This is the type discussed here.

Composition: Formula #2

Casings: These measure 5/8" I.D. x 3/4" O.D. x 1" long. End caps are made to fit flush over their ends, rather than fit inside the ends or in the care of M-80s and Silver Salutes. However, since their end plugs are rather difficult to obtain or make, the "Acceloseal" method can advantageously be used for plugging the ends.

Ignition Device: 3/32" safety fuse.

Materials: Modified Professional Pyro Adhesive.

Tools: Same as for Silver Salutes except the case former should be 5/8" diameter.

Manipulation and Procedure: Roll the casing as described under Silver Salutes, using a piece of paper 36" x 28". Cut to length when dry and punch a small hole in the middle of the casing and insert a length of safety fuse. Apply some adhesive around the lip of the end cap and put it over the other end cap as before.

Note: If the fuse hole is made too large in Cherry Bombs and Super bull Dog Salutes, it may be necessary to add a dab of adhesive to keep the fuse in place during the dipping process.

IMPORTANT: The safest way to make salutes or any exploding device is to introduce the composition in two separate portions, first the required amount of oxidizer(s), and then the required amount of the other ingredient(s). In this way there is no large amount of explosive composition in any one place, nor is there, in fact, any explosive composition until the two portions are mixed inside the casing.

The scoop sizes for introducing these two portions must be found by experimentation. One scoop is used for the oxidizer(s) and another is used for the remaining mixture. Mixing the two portions can be done by placing a number of the completed salutes or other exploding devices in a large cardboard box, closing the lid and then gently turning the box over a few times. This is another reason exploding devices are only partially filled; it facilitates mixing of the components as well as giving an increased report.

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EXPLODING FIREWORKS PART II (L-102B)

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EXPLODING FIREWORKS (PART II)

I. INTRODUCTION

Explosive sound has a legitimate place in fireworks but only if used with responsibility. Fireworks that explode with a snap, tremendous report, or anywhere in between are very exciting. However, they are also very dangerous to shoot and even more so to make. Many individuals have been seriously injured trying to make or use these items. All of these accidents could have been avoided if the individuals involved had had an adequate knowledge of the principles, theory, and safety precautions pertaining to these items. Thus, all safety precautions given in this treatise must be followed to the letter.

Certain principles of pyrotechnic theory are given so the pyrotechnist can better understand the processes that are involved in making exploding fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, viz. a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition, casing, nor ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulations and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility for use.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

Table L-102B-1 Composition formulas

Formula #	Ingredient	Parts
1	Potassium Perchlorate	7
	Aluminum, dark pyro dust	3
2	Potassium Perchlorate	73
	Sodium Salicylate, USP,	26
	Red Iron Oxide	1
3	Potassium Perchlorate	40
	Magnesium, 100 mesh	34
	Aluminum, dark pyro dust	26
4	Potassium Chlorate	30
	Antimony Trisulfide	10
	Lampblack	10
	Aluminum, dark pyro dust	10
	Barium Carbonate	1
5	Potassium Perchlorate	3
	Barium Nitrate	3
	Aluminum, dark pyro dust	4

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II. EXPLODING CONES

All of these unusual items use paper cones similar to the ones on which thread or twine is wrapped. They look like the standard display cones but are actually the loudest of all ground noisemakers, along with the larger sizes of Cannon Crackers.

A. Black Volcano's

Composition: Formula #1.

Casings: A paper cone described above. These can also be obtained from Westech.

Ignition: 3/32" or 1/8" safety fuse.

Materials: Pro. Pyro Adhesive: 1/8" chipboard.

Manipulation and Procedure: Cut a disc from the chipboard with a diameter equal to the diameter of the cone at about 1/2 its height. Insert a fuse in the top of the cone and secure it with a dab of Adhesive. Allow to dry a few minutes, then fill about 3/4 full with powder. Insert the chipboard disc and secure and reinforce with plenty of Adhesive. Leave in the inverted position until dry.

B. Whistling Devils

These are the same as above except they begin with a long shrill whistle and then explode.

Compositions: Formula #2 (whistle); Formula #1

Casings: Same as above except with a slight modification, The nose of the cone must be clipped off to allow for the insertion of the whistle tube. The whistle casing itself should be 3" long x 5/16" I.D x 1/2" O.D. It must be rolled from a smooth type of paper such as the type used in post cards. A rough paper will affect the whistle tone adversely. Kraft and Manila papers may be used with almost as good results.

Ignition: 3/32" or 1/8" safety fuse, priming.

Materials: Same as above.

Tools: Wooden dowel or aluminum rod 5/16" diameter x 8" long, a ramming base for making the whistle. This is made as follows: Drill a hole 5/16" diameter and 1/2" deep in the center of a block of wood at least 2" square and 1/2" thick. Insert and glue in place a piece of wooden dowel (or aluminum rod) 5/16" diameter and 1-1/4" long (cut from the 8" piece). The remaining 6-3/4" piece will be used to press the whistle composition into the case.

Manipulation and Procedure: Wet-roll the whistle casing and allow to dry at least two days. When dry, place over the ramming base nipple and press Formula #2 into it, using small quantities until the composition is 1/4" from the top of the casing. Remove from the base and prime both ends well. Insert a fuse in the end which has the 1" vacancy. This space is necessary for the proper production of the sound. When the priming is dry, insert the whistle into the nose of the cone and secure from the inside with Adhesive. Fill 3/4 full with Formula #1 and secure with the chipboard disc as before.

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C. Block Busters

These are the same as Black Volcano's except Formula #3 is used. These are extremely powerful and loud so the greatest of caution must be exercised. As with the Volcanoes, the powder charge must not be confined, so cut the chipboard disc accordingly.

III. TORPEDOES

These are small spheres that explode when thrown against a hard surface, Their composition is one that is very sensitive to friction or shock. Use of extreme caution must be taken at all times when making or using them.

Composition: Formula #4. This is the one exception where chlorate/sulfur (or sulfide) are together. Thus, this formula is extremely hazardous. Under no circumstances should more than a gram or two of this composition be made at one time.

Casings: These are small cups of paper about 3/4" in diameter and 3/4" deep. These fit together to form a capsule similar to a Cherry Bomb casing. These too are such that they must be punched out by a machine and cannot be made by the pyrotechnist. They may be purchased from Westech.

Materials: Fine gravel that is clean and coarse; Sodium Silicate (water glass); tissue paper (any type of thin paper will do).

Tools: 22 cal. long rifle shells (to be used as measuring scoops); safety goggles, or face shield; safety gloves.

Manipulation and Procedure: Pour three scoops of Potassium Chlorate in the inner cup of the casing Place on top of this, without mixing, two scoops of the mixture of the other ingredients, then one pinch of gravel. -Close the capsule with the outer cup. Fill a small bowl with the Sodium Silicate and dip the completed capsule in it. It does not matter if their contents mix now. Take the greatest of caution once these chemicals begin to mix as they are very friction sensitive. Remove the capsule from the bowl (it need only be immersed a few seconds) and cover with small pieces of tissue paper until the capsule is completely covered with them and assumes a spherical shape. Allow to dry in a safe place. An alternate outside covering is a thick mixture of fine sawdust and Sodium Silicate. Keep dipping until the capsule assumes a spherical shape. Use heavy safety gloves and goggles for this operation. The gloves also make it possible to apply the outer coating easier.

IMPORTANT Use the utmost of caution when using and do not throw near any people because the gravel is impelled with considerable force with the explosion

The manufacture of these items is only recommended to pyrotechnists who have plenty of experience in making other fireworks items, and are cognizant of the precautions and dangers incident to Potassium Chlorate usage.

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EXPLODING FIREWORKS (PART II)

IV. MUSICAL SALUTES

These ever popular items have gone by a variety of names such as "chasers," "Whistling whizzers," "whistling tornadoes," etc. They scoot along the ground while whistling and smoking, finally ending with a loud report.

Compositions: Formula #2 (whistle); Formula #1.

Casings: These are wet-rolled from Kraft or Manila paper. Their dimensions are 5/16" I.D. x 1/2" O.D. x 4-3/4" long.

Ignition: Safety fuse, Priming.

Materials: Wrapping tissue.

Tools: Same as for "Whistling Devil" cones.

Manipulation and Procedure: Place the casing over the nipple on the ramming base and press in Formula #2 in small portions until it has the height of about 1-1/2" inside the tube. Pour in a small quantity of Formula #1 DO NOT RAM THIS. Remove from the ramming base and wrap the tissue paper cut in 2" x 6" around it, tucking in the overlapped portion that extends over the end with the salute composition. To further secure this end, apply a dab of paste. Then insert some priming in the other end so it covers the whistle composition surface and insert a length of safety or other type of fuse. Twist the overlapping portion of tissue paper around the fuse to secure it and allow to dry.

V. AERIAL FLASH BOMBS

All types of aerial flash bombs consist of a paper tube secured to a wooden base. Just above the base is a piece of safety fuse that protrudes through a hole punched in the tube. Inside the tube is a small quantity of Fg powder and a large salute with a time fuse. The black powder, upon ignition from the safety fuse, shoots the salute high into the air at the same time igniting its time fuse. When the salute reaches its zenith, the time fuse ignites the salute composition with a tremendous flash-report. Aerial flash bombs are in a variety of sizes. Their sizes are listed below:

Table L-102B-2 Mortar tube dimentions

Paper Mortar Tubes			
#	I. D.	O. D.	Length
0	3/4	7/8	3-3/4
1	1	1-3/16	5
2	1-1/4	1-1/2	6-1/2
3	1-1/2	1-13/16	7-1/2
4	1-3/4	2-1/8	8-3/4
5	2	2-7/16	10
100	2-1/4	2-3/4	11-1/4

Salutes Casings			
#	I. D.	O. D.	Length
0	5/8	3/4	3/4
1	13/16	1	1
2	1	1-1/4	1-1/4
3	1-3/16	1-1/2	1-1/2
4	1-3/8	1-3/4	1-3/4
5	1-3/4	2	2
100		2-1/4	2-1/4

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EXPLODING FIREWORKS (PART II)

Table L-102B-2 Mortar tube dimentions continued

Wooden Bases	
#	Dimentions
0	1-1/2 x 1-1/2 x 3/8
1	1-3/4 x 1-3/4 x 3/8
2	2 x 2 x 1/2
3	2-1/4 x 2-1/4 x 5/8
4	2-1/2 x 2-1/2 x 3/4
5	3-1/2 x 3-1/2 x 3/4
100	3-1/2 x 3-1/2 x 3/4
3-shot	2-1/2 x 2-1/2 x 3/4
5-shot	3-1/2 x 3-1/2 x 3/4
9-shot	4-3/4 x 4-3/4 x 3/4

A. Single Report

Composition: Formula #5, Fg. black rifle powder (for the mortar lifting charge).

Casings: Both the mortar and salute should be wet-rolled from Kraft or Manila or Chipboard to the above dimensions. Be sure and apply plenty of force when rolling the mortar as it has to withstand the immense pressure of the lifting charge of black powder. Mailing tubes or other strong tubes may be used for the mortar with equal results.

Ignition: Mortar - 3/32" safety fuse; Salute-special fireworks time fuse, 1/4" or 3/8" diameter; Priming.

Materials: Pro. Pyro Adhesive; chipboard about 1/8" thick.

Tools: Wooden dowel or a metal pipe with an O. D. equal to the I. D. of the mortar (if the mortar is rolled by the pyrotechnist), another former (dowel or pipe) to roll the salute casing. (Westech has formers that are ideal for this purpose.)

Manipulation and Procedure: Punch a hole in the mortar about 1/4", from one end, cement it to the wooden base with the Adhesive and let dry. Plug one of the ends of the salute casing with Adhesive and an end Plug made from chipboard cut in a disc shape with a diameter equal to the I. D. of the salute. While this is drying, drill a hole in another chipboard disc equal to the diameter of the time fuse. Time fuse comes in various diameters the most common being 1/4", and 3/8". cut the time fuse to the proper length. (This must be ascertained by experimentation, depending on the effect desired and amount of lifting charge.) Secure it well with Adhesive and prime both ends well. The fuse should extend half its length inside the salute and half outside. When the Adhesive is dry, pour in enough salute powder to fill its casing about 3/4 full. Secure the remaining end plug with Adhesive, making sure the salute comp does not come in contact with the wet Adhesive. Pour in a quantity of Fg black powder. (This quantity must also be determined by experimentation, depending on the size of the salute.) Generally, the various amounts will be somewhere between 1/4 teaspoon to 2 teaspoonfuls.) Drop the salute, fuse end down, on top of the powder. Cut a circle with a diameter equal to the I. D. of the mortar from thin cardboard and Push it down on top of the salute to secure it and the driving charge in the mortar. Insert a length of safety fuse through the hole at the bottom of the mortar.

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B. Repeater

These are 3-, 5-, or 9-shot #0 aerial bombs arranged on one wooden base. They are matched with connecting lengths of safety fuse so that they go off in sequence one after another. The last shot in the 5- and 9-shot repeaters can be a larger sized bomb if desired.

VI. MISCELLANEOUS AERIAL SHELLS

A. Whistling Aerial Bombs:

These are made in the same sizes as the Aerial Flash Bombs, except there is no #0 size. They have the added effect of a screaming whistle as they ascend before the report.

Compositions: Formula #2 (whistle) and Formula #1.

Casings: Same as for Aerial Flash Bombs with the addition of a whistle casing with the following dimensions: 2 " x 5/16" I. D. x 1/2" O. D.

Ignition: Same as above, also some black match.

Materials: Same as above.

Tools: Same as for Musical Salutes and Aerial Flash Bombs.

Manipulation and Procedure: Make the whistle according to the directions given under Musical Salutes, except only make a column of whistle comp. about 3/41, high. Make sure the comp. is pressed very tightly since it has to withstand the pressure of the lifting charge without blowing through. Use adequate Precaution when pressing. Prime both ends heavily and insert two or three 1-1/21, lengths of bare match in the end with the 1" vacancy. These not only assure the ignition of the whistle but take off some of the pressure of the lifting charge. The matched and primed whistle takes the place of the time fuse. Secure it well in the hole of the end plug with Adhesive. Proceed as in Aerial Flash Bombs.

B. Thunder Shells:

These are also made in sizes from #1 on up. Instead of a single large report, they explode in many smaller reports. They are made the same way as Aerial Flash Bombs, except as many flashcrackers that will fit inside the salute casing are used instead of the salute composition. In addition, a small quantity of meal powder is also placed in with the crackers as well as some FFFg black powder. This bursting charge assures the ignition of all the crackers as well as scattering them over a wide area in the sky. In the larger sizes, salutes may be used in addition to crackers. It is not necessary to use thick-walled casings as used in Aerial Flash Salutes. Wet-roll all the aerial casings used in Thunder Shells with only a 1/16" wall. These shells are also known by other names such as "Battle-in-the-clouds, "Sky Racket Shells, " etc.

C. Rocket Shells:

Various manufacturers use this name to designate different shells. One type is merely another name for a Whistling Aerial Bomb. However, the type discussed here is a combination of a Thunder Shell with a whistle as it ascends. Follow the directions in parts A. and B. above to make this shell.

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D. Siren Bombs:

Again, various manufacturers use this name for different shells. One type is a Whistling Aerial Bomb. Another type is the same as a Whistling Bomb except it has two or three whistles burning at once as it ascends. This is a very effective piece of fireworks, and is the type discussed here. Only #3 sizes and larger should be made. Proceed the same as for Whistling Aerial Bombs except drill two or three holes in the end plug instead of one.

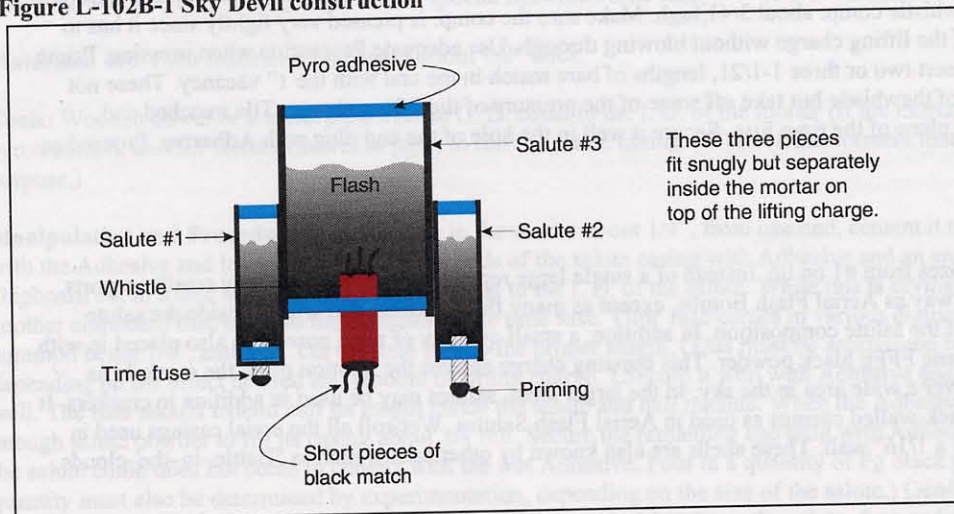
E. Thunderbolt Shells:

These are the same as Aerial Flash Bombs except Formula #3 is used instead of #5.

F. Sky Devil Shells:

This is a timed-reports aerial shell with a whistle as it ascends. Generally, these are made in only #5 and #100 sizes, but occasionally #3 and #4 are made. The mortar shoots a shell that whistles as it ascends. First one report is heard, then about one second later another report is heard, then 1-1/2 seconds later the whistle ends with an ear-splitting explosion. The first report is heard about 1-1/2 seconds after the mortar fires the shell. The total whistle time is 3-1/2 seconds. These shells require considerable skill to make as the time fuses, driving charge, and whistle composition. length require extremely accurate measuring and coordination. They are made like Rocket Shells except only two reports are put in the thin-walled casing instead of the many smaller ones. The last report is also put inside the casing but firmly cemented to the whistle with Adhesive. The whistle acts as its time fuse. All time fuses must be well primed. The whistle casing should be 3-1/4" long with about 2" of whistle composition. Only experimentation will tell the correct length of the time fuses and whistle comp. since all pyrotechnists work under different factors and use different materials and methods.

Figure L-102B-1 Sky Devil construction

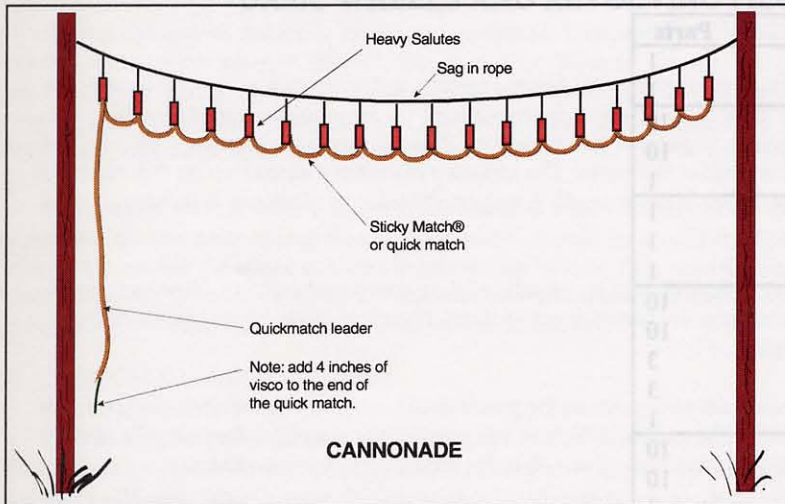


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EXPLODING FIREWORKS (PART II)

CANNONADES

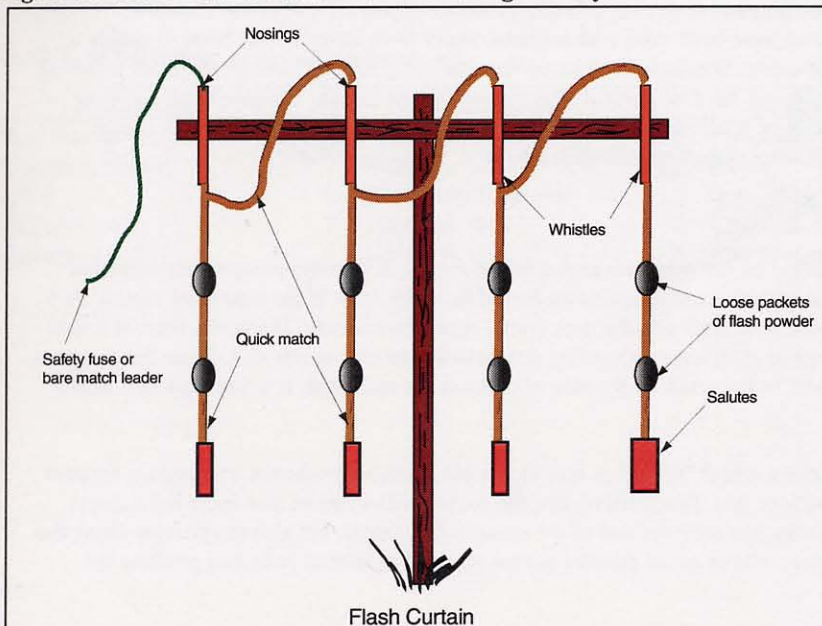
These are a long string of Cannon Crackers or salutes that are connected by quick match. When ignited their effect is like an old time cannon bombardment. Two posts (2" x 4's or larger) should be put in the ground about 20 to 50 feet apart.

Figure L-102B-2 Cannonade illustration



They should each be about 6' high. A strong wire is connected between the tops and a number of pieces of strong twine about 18 inches long are tied to it at 18 inches apart. The salutes are tied to these pieces of twine. Quick match is then led to each of them and secured in place with Adhesive. Make sure that there is a piece of bare match going into the salute and not all piped match. A long length of safety fuse or bare match is connected to the first end of quick match by twine. Another item similar to a cannonade is a "Flash Curtain" or "Whistling Fantasy" shown below.

Figure L-102B-3 "Flash Curtain" or "Whistling Fantasy"



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EXPLODING FIREWORKS (PART II)

RAINBOW REPORTS

These are formulas for flash powder that ignite with various colored flashes. If confined in even the loosest of containers they will still explode with a good-sized report.

Table L-102B-3 Rainbow report compositions

Color	Ingredient	Parts
Red	Magnesium, powder	1
	Strontium Nitrate	1
Green	Magnesium, powder	10
	Barium Nitrate	10
	PVC	1
Yellow	Magnesium, powder	1
	Sodium Oxalate	1
	Potassium Perchlorate	1
Violet	Magnesium, powder	10
	Potassium Perchlorate	10
	Cupric Oxide	3
	Strontium Nitrate	3
	PVC	1
Blue	Magnesium, powder	10
	Potassium Perchlorate	10
	Paris Green	3
	PVC	1/2
White	Magnesium, powder	1
	Potassium Perchlorate	1

NOTE: The Magnesium powder should be at least 100 mesh or finer.

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BASIC WHEELS AND REVOLVING PIECES (L-103)

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I. INTRODUCTION

Wheels and revolving pieces present to the pyrotechnist one of the best means to display his imagination and artistic ability to the fullest extent. So much can be created using so little actual physical means. Revolving pieces can be effectively used in the smallest backyard display, in medium-sized displays for groups, parties, or country clubs, to the largest stadium sized exhibitions. Many other forms of fireworks depend on size for their effect. This is true of "Niagara Falls" effects, and some aerial shells.

Revolving pieces provide not only showers of sparks and fire but motion and animation as well. Thus they are able to provide a varied and interesting display in themselves. Since many of the more interesting and artistic effects take much hand labor, revolving pieces in general, not to mention the more elaborate creations, have tended to disappear from exhibition as well as commercial fireworks. The serious pyrotechnist should not let this deter him from creating his own imaginative wheels, either large or small. A truly well balanced display will include a varied selection of revolving pieces.

Most wheels and revolving pieces can be constructed and displayed with comparative safety. However, there are some items that have more than uncommonly dangerous compositions. Therefore, all safety precautions given in this treatise must be followed to the letter.

Certain principles and pyrotechnic theory are also given so the pyrotechnist can better understand the processes that are involved in making revolving pieces. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since all fireworks items consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanisms necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition nor the casing but are necessary for their proper function) are listed. Fifth, any special tools that are required are if given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material, since we have no control over the conditions of use. The purchaser and user take full responsibility. Pyrotechnics can be a fascinating and rewarding occupation. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II THEORY AND GENERAL PRINCIPLES

Wheels and revolving pieces function on the same principles as the rocket. A burning composition confined within a cylindrical case produces gases which exert pressure on the walls of the case. If the case were closed, then the pressure would be exerted equally on both ends and the case would remain stationary. However, there is a hole in one end. This allows the gases to escape with a corresponding decrease in pressure at this end. Since the pressure at the opposite closed end is now greater as the result of the loss of gases at the open end, it pushes the case in the direction away from the closed end.

A difference between the rocket and a wheel "driver" is that the rocket needs to produce a tremendous amount of force within a matter of a few seconds or less. (To achieve this, the rocket is charged so that there is a conical hollow inside its powder core. In this way, not only the end of the composition burns, but also the powder along the walls of the hollow. A very large amount of area of the powder is thus allowed to burn at once and produce the needed force.)

On the other hand, wheel drivers are intended to produce a smaller sustained amount of force over a longer period of time. Thus they are charged without a conical hollow so only the end of the powder burns. So charged, there is less area of the powder to burn at once so it produces less force but over a longer period. There is much less force required in order to spin a balanced, light weight wheel around an axis than to overcome the force of gravity and project the same weight item upward to a great *height*.

BASIC WHEELS AND REVOLVING PIECES

Wheels are generally classified as to the number of drivers they have, i.e., "one case," "two case," "six case," etc. They can be "single action", only one driver burning at a time; "double action", two drivers burning at once; or "multiple action", more than two drivers burning at once. The various drivers and garnishments on wheels are fired with quick match or safety fuse. When effects are to be delayed, safety fuse is used. For simultaneous firing, quick match is employed.

Wheels can also be endlessly varied and garnished. Thus, there are "Reversing Wheels": wheels that start one way and then turn the other; "Colored", "Rainbow", or "Rosette" wheels: wheels that have small lances or colored pots attached to them so as to burn along with the drivers. Wheels with whistles and/or salutes, drivers with various compositions so as to vary their effects of sparks and flame as they turn. Stop start" wheels, "delay" wheels and many, many others, imagination is the only limit.

The actual wheels or other types of frameworks to which the drivers are attached should be as light in weight as possible but also quite strong. Ready-made wheels should be used if at all possible, since it is sometimes quite difficult to combine the above qualities in homemade wheels. Pine is an excellent material for the construction of frameworks, etc. Wheels and all lightly colored structures should be stained or painted a flat black so they are invisible and not interfere with the patterns of sparks and fire.

III. COMPOSITION FORMULAS

The more meal powder a composition has, the more force it produces. Thus for small or light-weight wheels, drivers may be used with smaller proportions of meal powder, or only one driver need burn at once. For heavier and more elaborate wheels, more drivers need to be fired at one time, or more meal powder be added to the composition. Only experimentation will tell how much meal powder to add to or delete from a composition, each type of wheel being different.

The size of a wheel will generally determine how rapidly it should revolve, and this, in turn, will dictate the amount of meal powder in the composition and/or the number of drivers burning at one time. In general, small wheels and saxons should revolve with great speed. Larger wheels should revolve quite slowly, but they should not be so slow as to cumbrously lumber around their axis. If any revolving piece or wheel revolves too slowly add meal powder; if it revolves too fast decrease the amount of meal powder. Refer to table L-103-1 (All parts are by weight.)

Table L-103-1 Driver composition formulas

#1 (Saxons)	#2 (Fierce Gold)	#3 (Chinese Gold)
Meal Powder	4 Potassium Nitrate	18 Potassium Nitrate
Potassium Nitrate	2 Sulfur	5 Sulfur
Sulfur	2 <i>FFFg Black Powder</i>	12 Iron, filings or borings
Charcoal, dust	1 Charcoal, dust	3 Charcoal, dust
Charcoal, mixed*	1 Charcoal, mixed*	2 Charcoal, mixed*

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BASIC WHEELS AND REVOLVING PIECES

Table L-103-1 Driver composition formulas continued

#4 (Brilliant Gold)		#5 (Silver)		#6 (Silver)	
Potassium Nitrate	18	Pot. Perchlorate	8	Potassium Nitrate	6
Sulfur	5	Aluminum, bright	2	Sulfur	1
Steel needle filings	12	Aluminum, flitters	1	Charcoal, dust	1
Charcoal, dust	3	Red Gum Yacca	2	Titanium, coarse	3
Charcoal, mixed	2				

***NOTE:** Charcoal, mixed, is a combination of various mesh sizes of charcoal. The more varied, the better. This will give a shower of sparks that will have immediate through prolonged burning duration. A general rule is that the larger diameter the driver, the coarser should be the charcoal.

IV. PRODUCTS OF MANUFACTURE

A. Single Case

Saxons

These consist of a single case made to revolve in a plane of its axis by jets of fire projected through holes, one at either end, and at right angles to the axis. Saxons revolve about a nail driven through the center of the case into a post or other support. They may be double action: both holes fire simultaneously, reinforcing each other; single action: only one end fires at a time, the other end starting just as the first finishes; or reversing: the second end fires after the first but reverses the direction of spin. Each of these varieties may also have one or two small cases charged with color compositions attached to the side of the case, producing a ring of color inside the fire of the saxon.

Composition: Formulas #1, #5, or #6

Casing: These should be wet-rolled of Kraft or Manila paper. They may be any size but those between 1/2" to 3/4" I. D. are generally used. The following proportions work well. Taking the inside diameter (I.D.) as 1, the outside diameter (O.D.) should be 1-1/2 x the I.D., and the length x 10 the I.D. The ends are closed with rammed, dry clay.

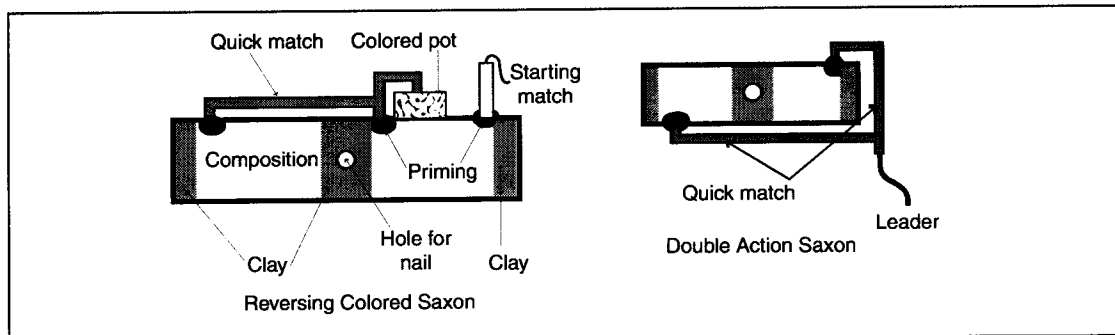
Ignition: Quick match, and black match (or safety fuse).

Tools: A rammer one inch longer than the length of the case and of the same I.D. It may be-cut from a wooden dowel or aluminum rod. A mallet preferably of rawhide, a drill (about 3/16" dia.), and a scoop to measure the correct amount of clay and composition.

Manipulation and Procedure: Stand the casing on one end on a firm surface, pour inn some-clay, and then ram solid with about ten blows from the mallet and hammer Enough clay should be used so as to make a plug the same thickness as 1/2 I.D. of the case. The whole quantity of clay should be introduced at once, not in many small portions. Now drive in small portions, Formula #1. Introduce just enough each time so when it is driven with ten blows it rises about one I.D. inside the case. When the composition reaches about 1/4" from the center of the case, clay is driven for 1/2". Then composition is again rammed so it comes to within one I.D. from the end of the case. Clay is then driven in to the top. A hole is bored about 3/16" in diameter and just through the case as near to each of the clayed ends as possible. If the saxon just to be "reversing", then drill holes on the same side; otherwise they are bored on opposite sides. Bore a hole all the way through the center of the case (where the 1/2" clay plug is located) at right angles to the other two holes. Now bore one more hole just through the case as near to the center clay portion as possible and on the same side to one of the end holes. Insert a piece of quick match in this hole, lead it over the center clayed portion and insert in the hole on the opposite end. Insert a piece of blackmatch or safety fuse in the hole at the other end. Before the match is inserted, all three fuse holes should be well primed. After the priming is dry, the whole saxon should be rolled up in a few turns of paper to secure the quick match and protect the holes from any premature ignition from sparks.

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BASIC WHEELS AND REVOLVING PIECES

Figure L-103-1 Reversing Colored Saxon



B. Flying Dutchmen

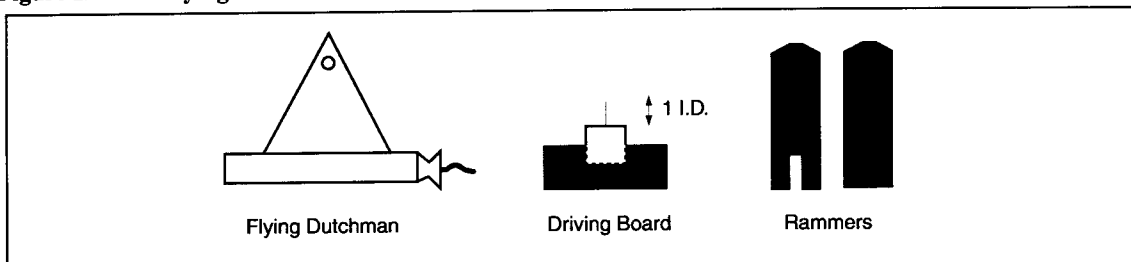
These also go by other names, sometimes being classified as Triangles, or as Saxons, or in a class by themselves. They have the same composition, casing, and ignition as the Saxon.

Materials: Professional pyrotechnic adhesive, a triangular piece of wood (pine is good) or 1/8" chipboard. It should be cut in an equilateral triangle, each side having the length of the casing minus two I.D. A hole should be bored through one of the angles as shown.

Tools: A special ramming base described as follows: drill a hole the same diameter as the I.D. of the case and 3/8" deep in a block of wood. Insert and glue in place a piece of wooden dowel 1/2" long. When the glue is well dried, drill a hole in the center of this dowel 3/8" deep x 1/3 the I.D. Insert in this hole a dowel cut so that it protrudes above the surface of the larger dowel the length of 1/2 I.D. of the casing. Two rammers both 1" longer than the casing and of the same I.D. One should have a hole drilled in one end such that the rammer can fit over the smaller of the two dowels of the ramming board. A mallet, preferably of rawhide, and a scoop for measuring composition and clay are also needed. Of course, aluminum will make better tools than wood.

Manipulation and Procedure: Slip the casing over the ramming base and using the rammer with the hole, ram in with ten good blows enough clay to form a thickness of 1/2 I.D. As always, the clay should be poured in all at once. Now drive a scoopful of composition with ten good blows. The scoop should hold just enough composition so that when it is driven it rises about 1/2" within the casing. Continue driving composition until it has come to within 1 I.D. of the top of the casing. Now drive in just a small amount of clay to cover the composition. Prime the fuse hole and cavity well and insert a fuse. When the priming is dry, roll a few turns of paper around the casing. The paper should be long enough so it extends about 1-1/2" past each end. These loose ends are called "nosing." They should be twisted and tucked into each end of the casing and around the fuse to secure and protect it from premature ignition. The completed casing should now be attached with dabs of professional pyro adhesive to the triangular piece of wood. Refer to figure L-103-2.

Figure L-103-2 Flying Dutchman and tools

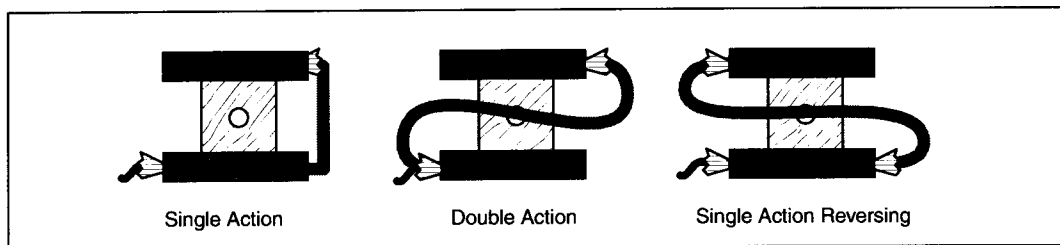


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BASIC WHEELS AND REVOLVING PIECES

C. Two Case

Two Case are sometimes classified as Triangles but are most often known as "Comet Wheels" They may be single or double action. They are made exactly like the above but attached to a square piece of light wood instead of a triangular piece. Each side of the piece of wood has the length of the casings minus two I.D. Also, if it is to be single action, the first driver is not closed with clay at its butt end. Instead it is primed and a length of quick match inserted. This is then lead up to the nozzle end of the other driver. In the case of double action wheels, both butt ends of the drivers are closed, the nozzle on the second driver being connected to the nozzle of the first by a length of quick match. Any of the composition formulas that do not have much meal powder may be used for double action wheels. Single action wheels will require compositions with more meal powder.

Figure L-103-3 Two case "Comet Wheels"



D. Three Case (Triangle Wheels)

These also are in various forms, some having six-sided blocks, others with three. Since the six-sided are the most common, its construction is given here.

Composition: Formula #2.

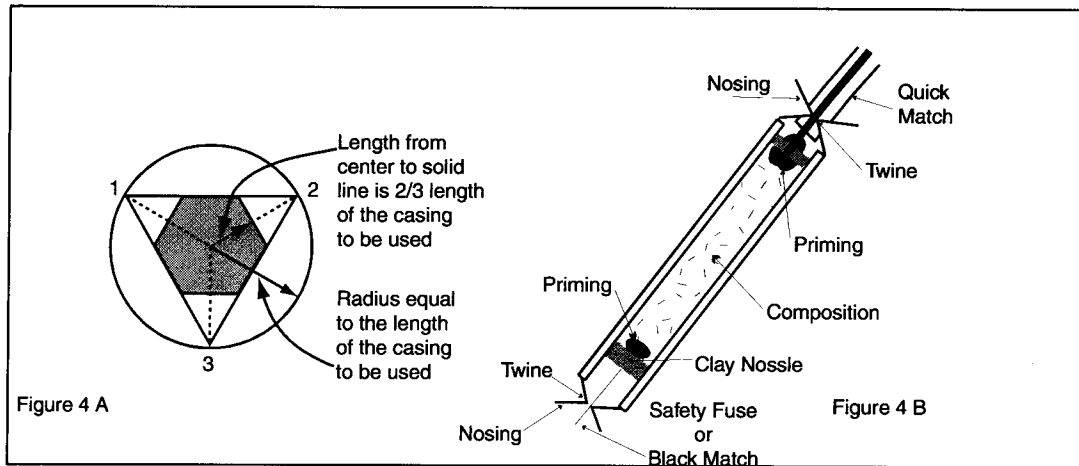
Casing: Same as the Saxon. Triangle casings generally are not larger than 5/8" I.D.

Ignition Materials: Quick match or safety fuse, priming.

Materials: Prof. pyro. adhesive, a six-sided piece of 1/8" chipboard constructed follows: With a compass, draw a circle with a radius equal to the length of the casing to be used on 1/8" thick chipboard, marking the center. Using the same radius, divide the circumference into six equal segments and draw lines connecting alternate intersections, 1, 2, 3, forming an equilateral triangle (see Figure L-103-4 A). Now draw three lines from the center to each of these points (shown dashed). Draw lines at right angles to these dashed lines a length of 2/3 the length of the casing to be used from the center. The area shown as shaded can then be cut out and a hole drilled in the center, slightly larger than the nail on which it will spin. This wooden base can be used as a template to outline additional ones, or a cardboard or metal pattern can be made for the same purpose.

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Figure L-103-4 Triangle wheel driver construction



Tools: Same as Flying Dutchman.

Manipulation and Procedure: All drivers are rammed as described under Flying Dutchmen, except the first two drivers are not closed with clay at their butt ends. Refer to Figure 4B. Roll a few turns of decorative or other paper around each casing as described for making a nosing. With dabs of professional pyro. adhesive, attach a driver to each of the smaller sides of the block of wood. Prime all nozzle holes and open ends well. Insert a length of safety fuse into the nozzle hole of the first driver and connect the butt end of the first driver to the nozzle end of the second with a length of quickmatch. Connect the second driver to the third in the same way with quick match. When the priming is dry (allow a day or two), twist the ends of the outside wrapping of paper around all match and fuse connections, further securing these by tying with twine.

E. Multiple Case (Vertical Wheels)

These are constructed by fastening four to eight drivers to a wooden wheel made for this purpose. The wheels are usually 18" in diameter, or less. On good vertical wheels, the composition of the various drivers, or sets of drivers, should be varied and increase in effect as the burning proceeds. For example, the first case is charged with plain driving composition, the second with steel filings, the third with pieces of cut stars, etc. Also, the larger wheels may be garnished with various colored pots, whistles, salutes, reverse their direction of spin, etc.

Compositions: Any.

Ignition: Quick Match, priming, safety fuse.

Casings: Same as for Triangles, using 3/4" I.D. or less.

Materials: Same as for Triangles except wooden wheels are used instead of a wooden block.

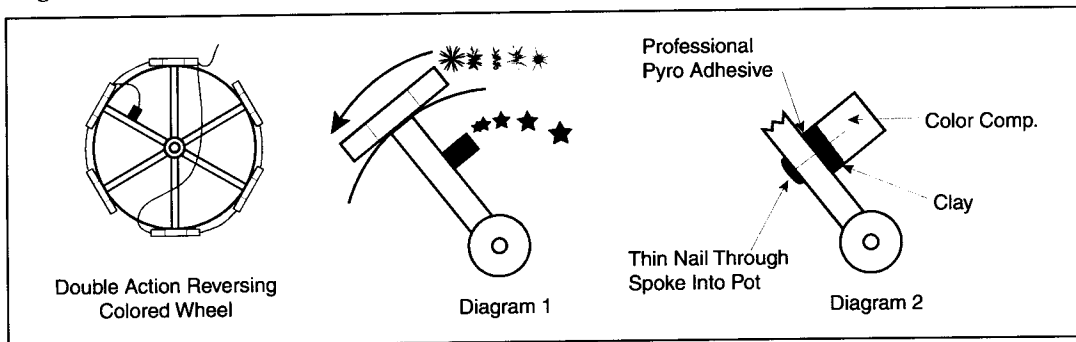
Tools: Same as for Triangles.

Manipulation and Procedure: Same as for Triangles. The cases and garnishments should be attached to the wheels with small dabs of professional pyro. adhesive, and tied with twine or #18 gauge annealed iron wire. Colored pots should be placed on the inside of the spokes, (not facing toward you) and so that the direction of the spin is away from the burning end. This is to keep the pot burning evenly (see diagram 1). Care should be taken to be sure and use strong burning color compositions for pots and lances. In order to be strong burning, the compositions must be well mixed. Use mixing sieves. If they are not well mixed, they will not burn evenly and with enough force to keep from being blown out by the revolving wheel. This is especially true of those placed nearer the outside. Colored pots and lances must burn the same length as the drivers, all stopping at the same time. If colored pots are not well secured to the wheel, they are easily thrown off. Use small wire nails and a dab of professional pyro. adhesive to secure them in the same manner as lance work (see diagram 2). Garnishments should

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BASIC WHEELS AND REVOLVING PIECES

be placed so they balance the wheel as nearly as possible. Make sure all quick match connections are tight. They should be tied with twine whenever they cross a spoke or touch the wheel rim.

Figure L-103-5 Multiple case wheel detail



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EXHIBITION WHEELS AND REVOLVING PIECES PART I (VERTICAL) (L-103A)

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(L-103A)
PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

I. INTRODUCTION

The single wheels and revolving pieces that make up this class are generally 24" in diameter or larger. Where multiple wheels are used, smaller sizes are employed. However, smaller scale versions can be made and be very effective even for small backyard displays.

All of the general principles, theory, formulas, safety precautions, etc. that were discussed in L-103 should be observed and applied. All wheels, frameworks, and other structures should be well constructed and as light in weight as possible.

The turning cases on large revolving pieces should be of various diameters. The largest sizes should start the wheel spinning and then the drivers should become progressively smaller. This is because when the wheel is first fired, all the cases are still charged and the wheel is quite heavy. As the cases progressively burn, the wheel becomes lighter and less force is needed to make it revolve. Whenever a wheel is to reverse, the same size driver(s) as the previous one(s) should be used, as additional force is needed to stop the spin and start it in the new direction.

When creating your own effects, care should be taken not to have too many different effects happening at the same time. Otherwise the display is mere confusion. Imagination should be tempered with good taste. For example, do not have a revolving sun with an outside set of gold drivers, then a small wheel with silver drivers in the center spinning the opposite way, and colored pots between these two. Generally, only two different kinds of visual effects (direction of wheel spin, turning case composition, color pots, etc.) may be happening at one time. Audio effects such as whistles may be added whenever desired without bringing confusion. Such pointed audio effects as salutes require more discrimination and are usually saved for a finale.

When matching small wheels or saxons to larger revolving pieces, care should be taken to not allow the quick match pipe to be secured inside the small driver's nosing (or saxon's outer wrapping of paper). If this happens, the smaller piece may be chained to the larger piece with the match pipe and not revolve. A good way to avert this is to allow the piping to enter and leave the nosing as usual but tie the nosing around the bare match instead of the pipe. Also, use a quick match made with good quality powder (either commercial meal powder, or the type described in L-TR4). If inferior powder is used, it will not have enough force to blow the pipe and match connection free.

Note: In general, all exhibition wheels should be placed on wooden posts six to twelve feet above the ground.

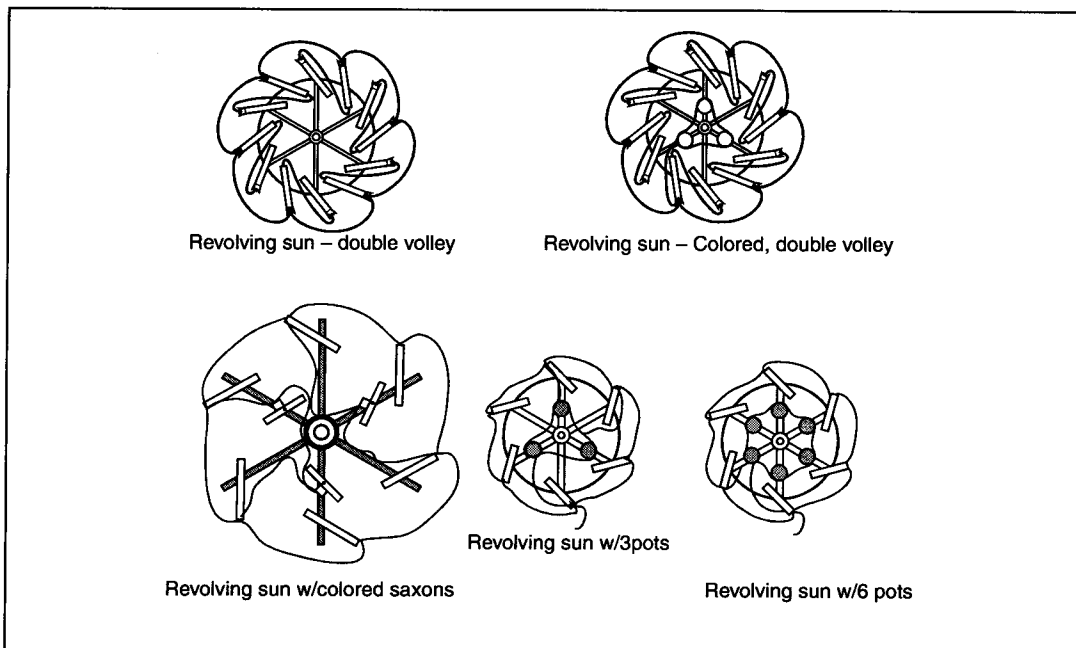
II. PRODUCTS OF MANUFACTURE

A. Revolving Suns

These are light wooden frames made in the shape of the spokes of a wheel. They generally have six spokes but may have more. They may be colored, or garnished in many ways. Sometimes they have two rims to which are attached the gerbes. Revolving suns differ from regular vertical wheels in that they have gerbes rather than drivers to propel them. Gerbes have less meal powder than wheel drivers. Gerbes are meant to provide more of a shower effect instead of motive force. Thus, revolving suns usually have six or more gerbes firing at once to provide enough force to turn them. It is for this reason that revolving suns are usually not made to reverse. The second set of drivers would be hard pressed to stop the spin and start the device revolving again in the opposite direction. Revolving suns should start to turn very slowly and then continue to turn with a regular movement. Revolving suns also differ from wheels in that the turning cases are placed obliquely around the circumference, rather than tangentially. The correct angle is about 45° degrees. This is best done by attaching each driver to the rim and to a spoke. If the number of drivers (gerbes) is greater than the number of spokes, then a smaller inner rim is used and the gerbes attached to the two rims. Refer to figure L103A-1.

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PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

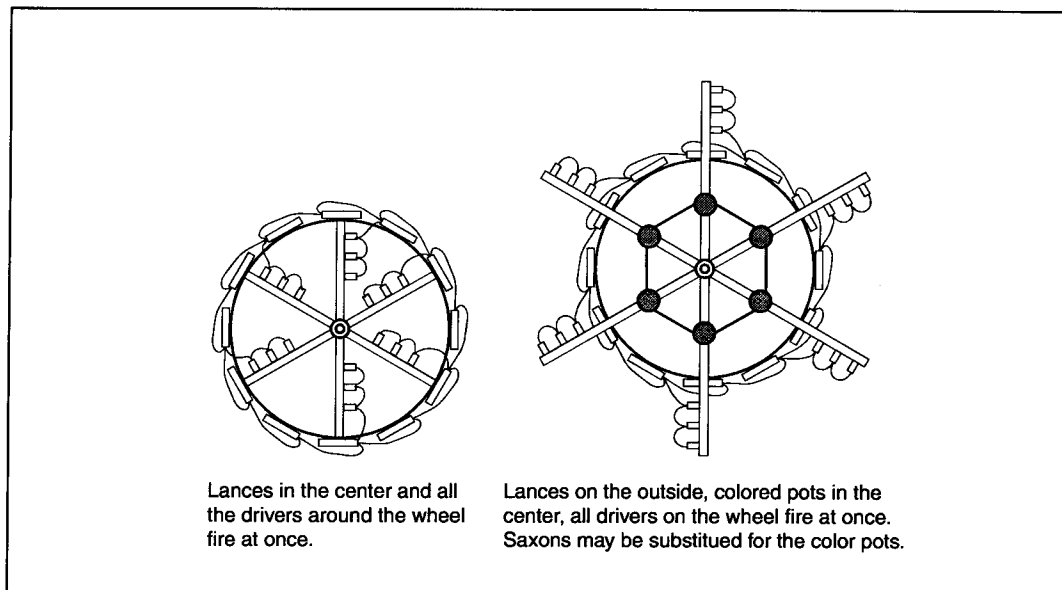
Figure L103A-1 Revolving suns



B. Compound Exhibition Wheels

These are essentially large, multiple action vertical wheels that are heavily garnished. Refer to figure L103A-2.

Figure L103A-2 Compound exhibition wheels

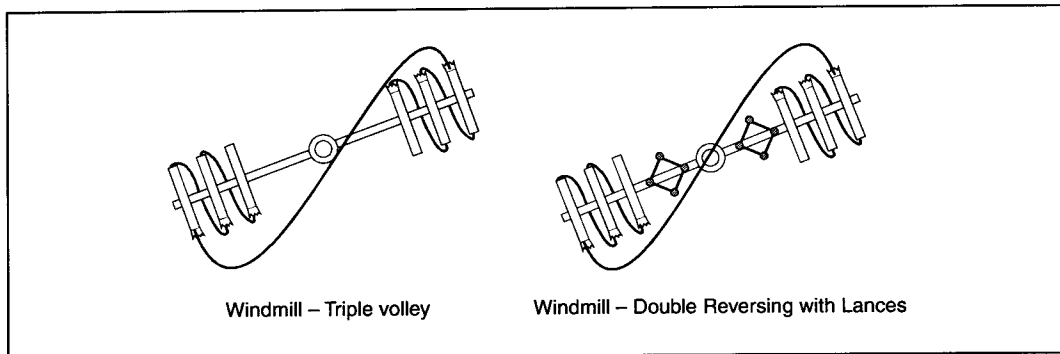


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PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

C. Windmills

These are made of long, thin, light pieces of wood with an axle hub in the center. At their extremities are drivers placed at right angles that fire in pairs (one at each end). The amount of meal powder in the turning cases will vary greatly depending upon the size of the piece and type of garnishments. They may be reversing or one-way. Refer to figure L103A-3.

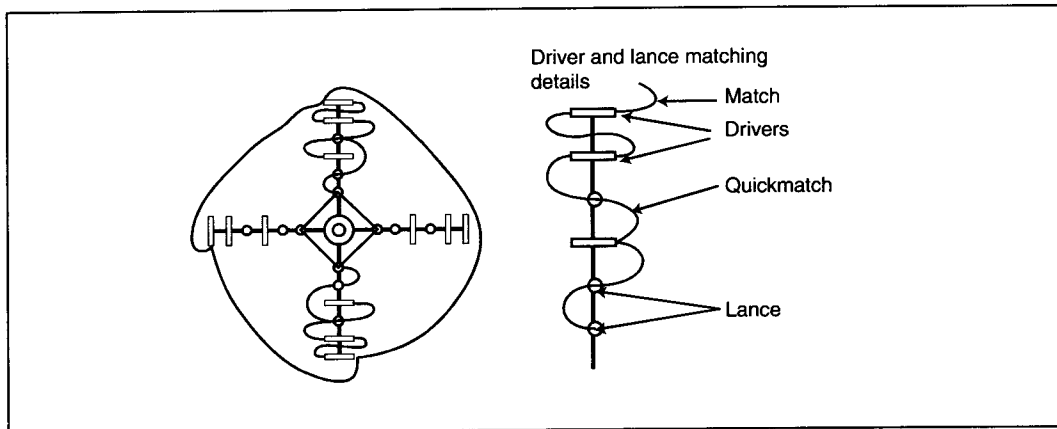
Figure L103A-3 Windmills



D. Transformation Wheel

The following piece is very effective. The colored pots are charged with it very bright color composition and the drivers only with meal powder and charcoal dust. The proportions must be determined with experimentation, depending upon the size of the piece. Start with about 84 parts meal powder to 16 of charcoal. This driver composition will give very few sparks and if the colored pots are bright enough, they should hide the sparks with their brightness. All that will be seen is a circle of revolving flares without any visible motive force, the roar and hiss of the invisible drivers adding to the effect. Refer to figure L103A-4.

Figure L103A-4 Transformation wheel detail



Also very effective is to start a similarly constructed piece with regular gerbes and no colored pots. Have the last drivers be of the meal powder/charcoal composition and fire the bright flares at the same time. What results is a very effective "Transformation Wheel" transforming itself from a regular type wheel display of golden showers to one of bright revolving colors.

(L-103A)

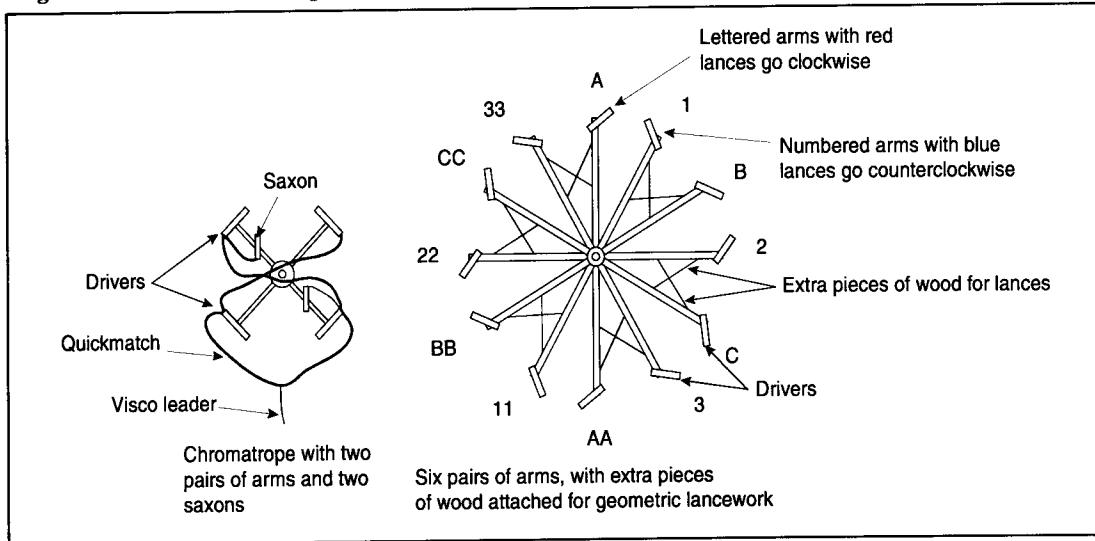
PART I (VERTICAL)

EXHIBITION WHEELS AND REVOLVING PIECES

E. Chromatopes

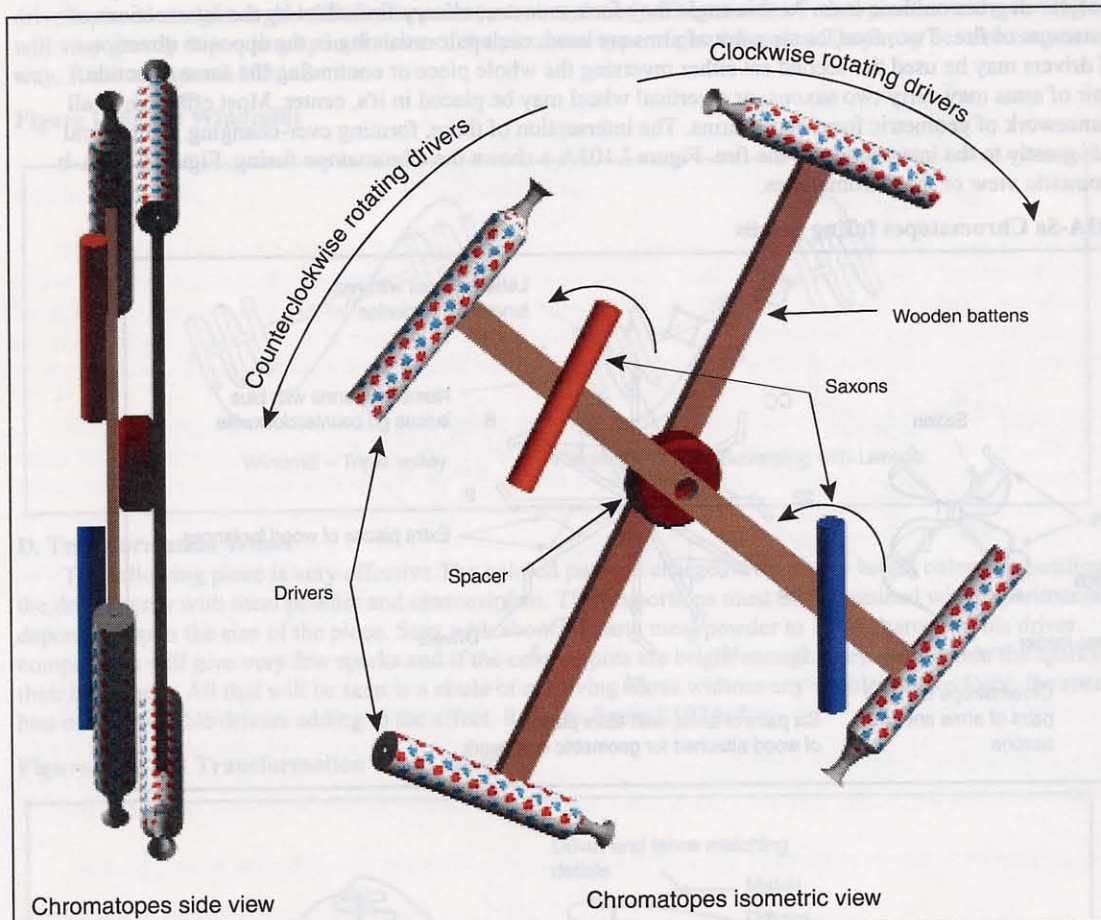
These make an extremely effective display. They are flat bars of wood pivoted in the center with driver, placed at an angle of 45° degrees on their ends. At this angle they form an extraordinary fire effect by the intersections of the various streams of fire. Two, four, or six pairs of arms are used, each pair revolving in the opposite direction. Two sets of drivers may be used the second set either reversing the whole piece or continuing the same direction. The front pair of arms may carry two saxons, or a vertical wheel may be placed in it's, center. Most effective of all is to place lancework of geometric form on the arms. The intersection of these, forming ever-changing geometrical designs, adds greatly to the intersection of the fire. Figure L103A-a shows the Chromatope fusing. Figure L103A-b shows an isometric view of the Chromatopes.

Figure L103A-5a Chromatopes fusing details



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PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

Figure L103A-5b Chromatopes isometric view



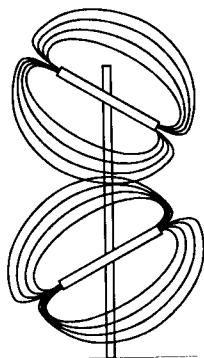
F. Multiple Exhibition Vertical Wheels

These are many vertical wheels placed in some type of a pattern. They are very effective if they are reversing-the whole pattern changing direction one or two times. Also very effective is to vary the driving composition so all wheels fire with one type and then change to another. Of the utmost importance is that all corresponding drivers on the various wheels burn the same length. This is effected by charging them with the same weight and same type of composition and ramming them the same amount. Refer to figure L103A-6

Also very effective is to start a similarly constructed piece with regular pattern and no colored pins. Have the last drivers be of the usual powder/charcoal composition and fire the bright flames at the same time. What results is a very effective "Transformation Wheel" transforming itself from a regular type wheel display of golden showers to one of bright flashing colors.

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PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

Figure L103A-6 Vertical exhibition wheels

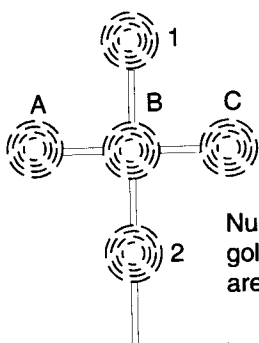


Mystic Circles



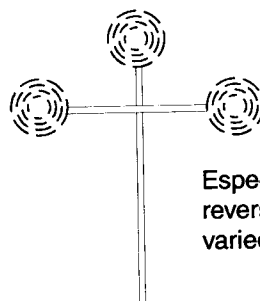
Diamond Broach

Middle gold wheel goes one direction, outside wheels (silver) turn the opposite way.



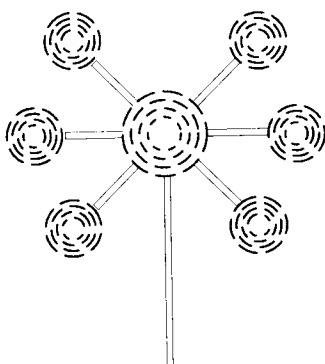
Flitter Set

Numbered wheels are gold, lettered wheels are silver.



Three Musketeers

Especially effective with reversing wheels and varied driver compositions.



Golden Cluster

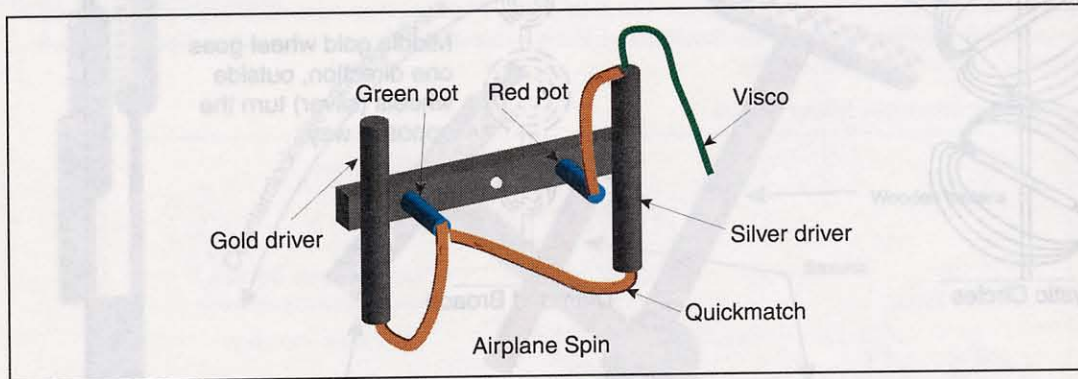
Gold outside wheels go clockwise, then change to counterclockwise. Silver inside wheel does the opposite.

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PART I (VERTICAL)
EXHIBITION WHEELS AND REVOLVING PIECES

G. Fancy Wheels

The Airplane Spin is constructed as shown. The first driver is silver and burns along with a red pot. The second driver is gold and burns along with the green pot. This is a very effective piece as it transforms itself from a red and silver wheel to a gold and green one. Refer to figure L103A-7

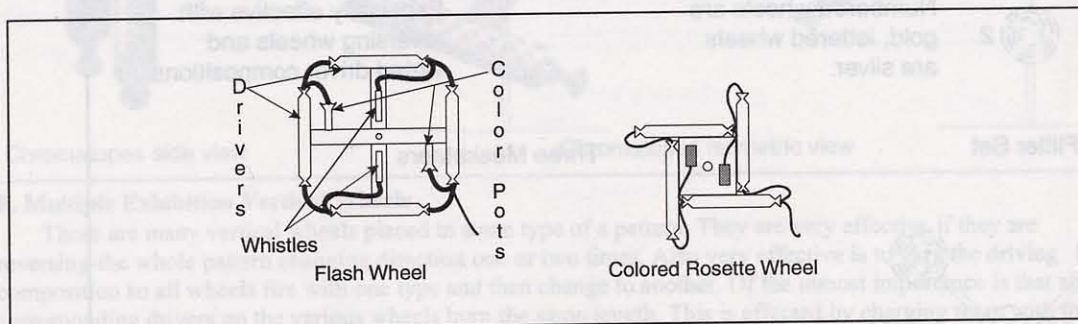
Figure L103A-7 Airplane spin illustration



The Flash Wheel is constructed as shown on the left hand side of the following illustration with whistles, and colored pots.

The Colored Rosette Wheel is a very beautiful piece. The two pots are red and all drivers are charged with formula #7. They are placed around a square piece of wood. Refer to the right hand illustration in figure L103A-8

Figure L103A-8 Flash and Colored Rosette wheels



EXHIBITION WHEELS AND REVOLVING PIECES PART II (HORIZONTAL) (L-103B)

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(L-103B)
PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

I. INTRODUCTION

The single wheels and revolving pieces that make up this class are generally 24" in diameter or larger. Where multiple wheels are used, smaller sizes are employed. However, smaller scale versions can be made and be very effective even for small backyard displays.

All of the general principles, theory, formulas, safety precautions, etc., that were discussed in L-103 should be observed and applied. All wheels, frameworks, and other structures should be well constructed and as light in weight as possible.

The turning cases on large revolving pieces should be of various diameters. The largest sizes should start the wheel spinning and then the drivers should become progressively smaller. This is because when the wheel is first fired, all the cases are still charged and the wheel is quite heavy. As the cases progressively burn, the wheel becomes lighter and less force is needed to make it revolve. Whenever a wheel is to reverse, the same size driver(s) as the previous one(s) should be used, as additional force is needed to stop the spin and start it in the new direction.

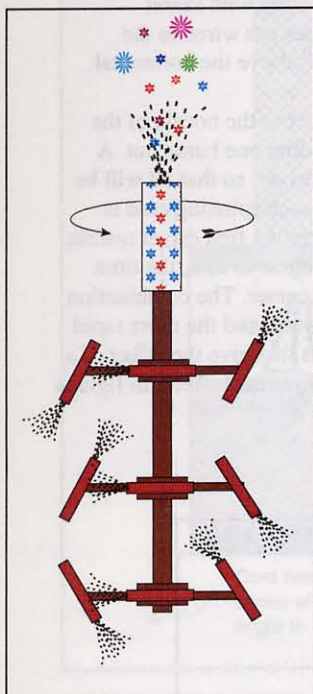
When creating your own effects care should be taken not to have too many different effects happening at the same time, otherwise the display is mere confusion. Imagination should be tempered with good taste. For example, do not have a revolving sun with an outside set of gold drivers, then a small wheel with silver drivers in the center spinning the opposite way, and colored pots between these two. Generally, only two different kinds of visual effects (direction of wheel spin, turning case composition, color pots, etc.) may be happening at one time. Audio effects such as whistles may be added whenever desired without bringing confusion. Such pointed audio effects as salutes require more discrimination and are usually saved for a finale.

When matching small wheels or saxons to larger revolving pieces, care should be taken to not allow the quick match pipe to be secured inside the small driver's nosing (or saxon's outer wrapping of paper). If this happens, the smaller piece may be chained to the larger piece with the match pipe and not revolve. A good way to avert this is to allow the piping to enter and leave the nosing as usual but tie the nosing around the bare match instead of the pipe. In general, all exhibition wheels should be placed on wooden posts six to twelve feet above the ground.

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PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

II. PRODUCTS OF MANUFACTURE

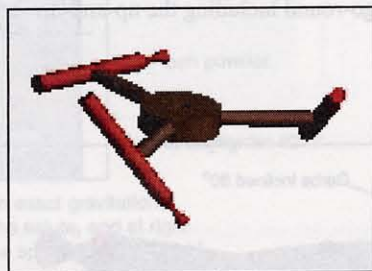
Figure L-103B-1 Caprice



A. Caprice

For a compact piece this is one of the most effective made. It consists of a wheel with three tiers of three cases each. Each tier is similar in appearance to three single triangle wheels superimposed at distances about equal to their diameter. Each case at the end of each spoke is so fixed that it varies the direction of the fire. The cases are led up in the following order: First, one case fires horizontally; then another fires upward; then another fires downward; then another fires horizontally; two cases now fire together (one up and the other down); finally the four remaining cases fire, one in each direction (one up, one down, one horizontal and one vertical). Refer to figure L-103B-1.

Figure L-103B-2 Caprice Drivers



B. Furiloni Wheel

This is similar to the Caprice. It has, however, two tiers of three cases each and one vertical fountain. Use formula 44. Refer to figure L-103B-2 for driver and tier construction.

C. Revolving Fountain

This is a very effective piece. It consists of a wooden hub bored to turn on a vertical spindle. It has two spokes fitted with gerbes for turning, and has playing vertically a large gerb and Roman candles. The turning gerbes play tangentially and slightly upwards.

D. Fiesta Display Wheel

This is also very effective. It consists of a hub like the above but with six spokes. The spokes are fitted with gerbes so that they fire in pairs, opposite each other. The center has a fountain matched to fire with the second set of gerbes. If these are gold, then the fountain should be silver. A battery of Roman candles fires with the third pair of drivers. A star, or spangle mine fires just as the last pair of drivers finish. A few whistles should also be added with the stars in the mine.

E. Devil Wheel or Devils at Play

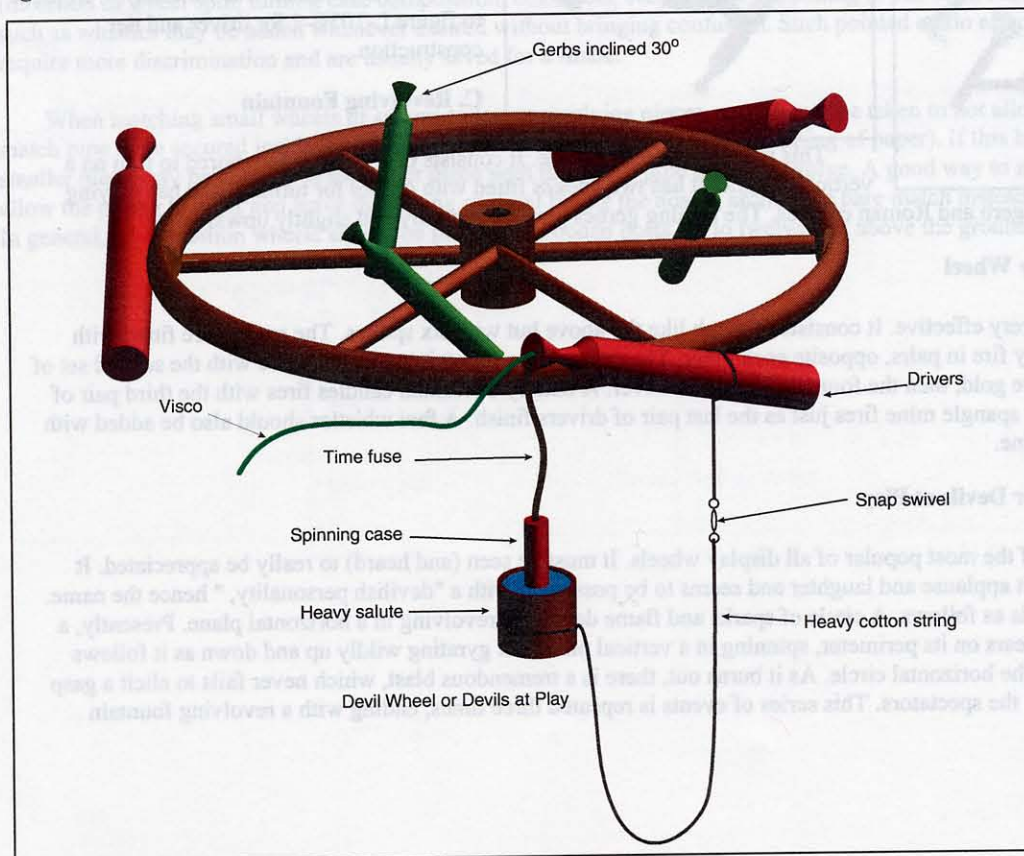
This is one of the most popular of all display wheels. It must be seen (and heard) to really be appreciated. It never fails to elicit applause and laughter and seems to be possessed with a "devilish personality," hence the name. Briefly, its effect is as follows. A circle of sparks and flame develops, revolving in a horizontal plane. Presently, a smaller circle appears on its perimeter, spinning in a vertical plane but gyrating wildly up and down as it follows the revolution of the horizontal circle. As it burns out, there is a tremendous blast, which never fails to elicit a gasp and laughter from the spectators. This series of events is repeated three times, ending with a revolving fountain spray.

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PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

A wooden wheel about two feet in diameter is needed. To its perimeter are attached three equally-spaced drivers. At the center of each driver a strong cord, about two feet long, is attached to the rim of the wheel by means of a swivel, similar to those used in fishing. Each of the three cords so attached is tightly fastened to the center of a large salute casing. From one end of the salute casing protrudes a small "spinning" case loaded with saxon composition so as to make it spin about the point to which the cord is attached. Three gerbes are wired to the spokes, about halfway between the rim and the hub and inclined upward at an angle of 30° above the horizontal.

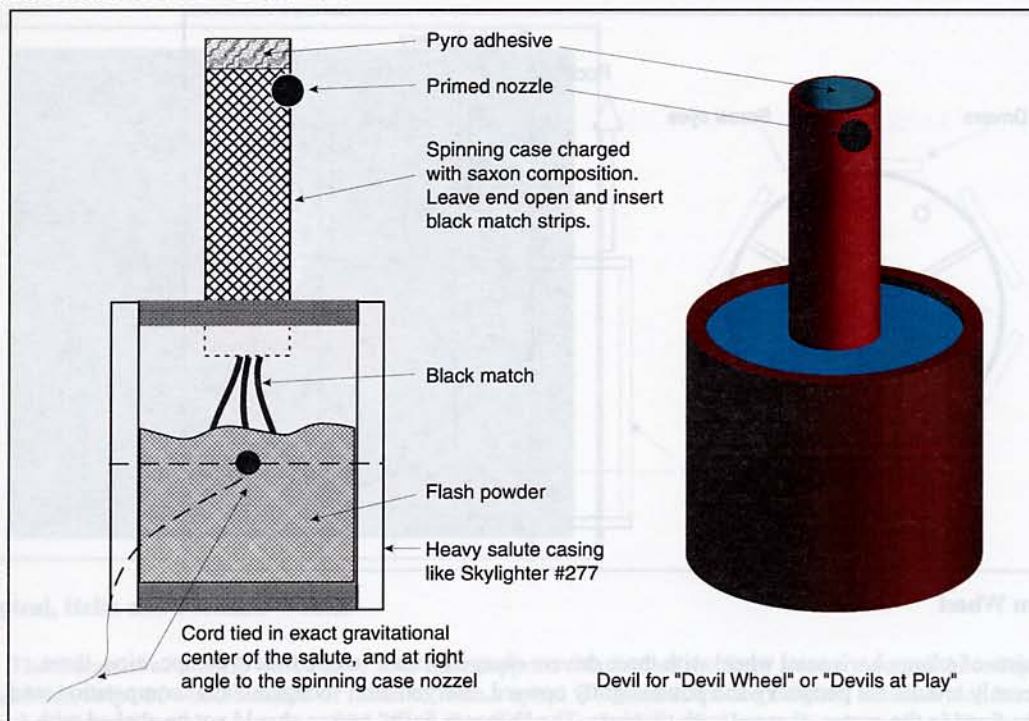
The wheel is matched as follows: quickmatch is run from the butt end of the first driver to the nozzle of the second, and likewise from the second to the third, so that each will be ignited as the preceding one burns out. A piece of quickmatch is run from the nozzles of all three central gerbes to that of the third driver, so that all will be lit at once as the latter begins to burn. Now a short time-fuse (1/8" safety fuse is good) of each spinning case is inserted into the nozzle end of the driver below which it hangs, and the "lead up" inserted in the first driver nozzle. The lead up fires both the first driver and its accompanying spinning case. As the wheel begins to turn, the time fuse supporting the latter burns through, and it drops to the end of the cord tied around its center. The combination of centrifugal force from the revolution of the wheel, which throws the spinning case outward, and the more rapid revolution of the latter about the point where it is tied, provides a combination of gyrations that give the effect of a pinwheel attached to one of the horses on a merry-go-round including the up-and-down movement. Refer to figures L-103B-3 and L-103B-4.

Figure L-103B-3 Devil Wheel



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PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

Figure L-103B-4 Devil Wheel Salute



F. Butterfly Wheel

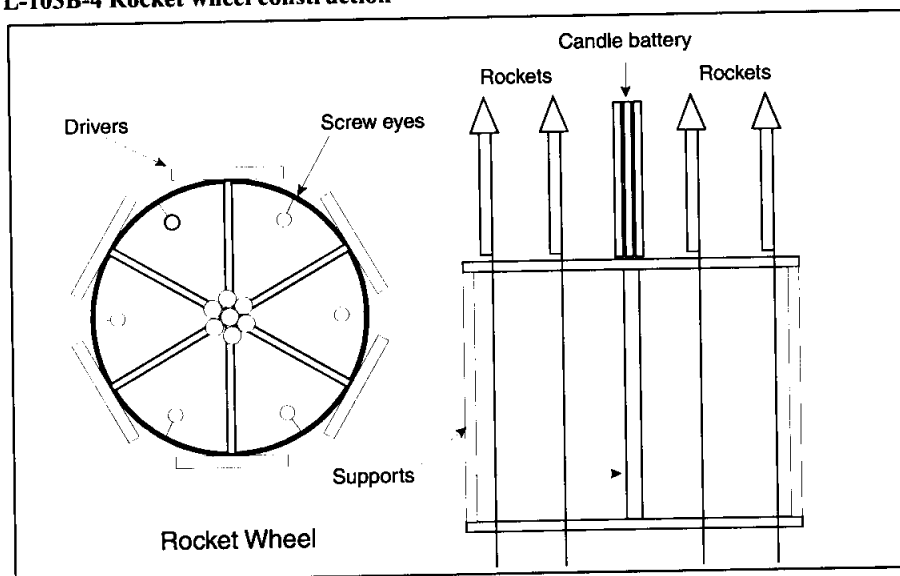
This consists of a large horizontal wheel with three drivers around the periphery matched to fire one after the other. There are also three vertical small wheels or saxons nailed to the rim and matched to fire along with the large drivers. A very effective combination is to have colored driver compositions in the small wheels or saxons (formulas 7-13) so as each of them fires, a new color is displayed.

G. Rocket Wheel

This is a very attractive piece. It consists of two wheels attached together by light wooden supports that are tacked to each wheel's rim. The top wheel's axle is plugged in its top third so the two wheels rest on a vertical rod and revolve horizontally. Around each rim are six screw eyes. Through these pass rockets that are matched to fire at intervals as the wheel revolves by being connected to successive drivers. On top is a battery of Roman candles, matched to fire with the second set of drivers. The top wheel is fitted with six "brilliant gold" drivers that are matched to burn two at a time, one each on opposite sides. The lower wheel is fitted with three or six gerbes wired to the spokes and rim and inclined upward at an angle of 30 degrees to give a wider spread of fire. These burn simultaneously with the last pair of drivers.

(L-103B)
PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

Figure L-103B-4 Rocket wheel construction



H. Snowstorm Wheel

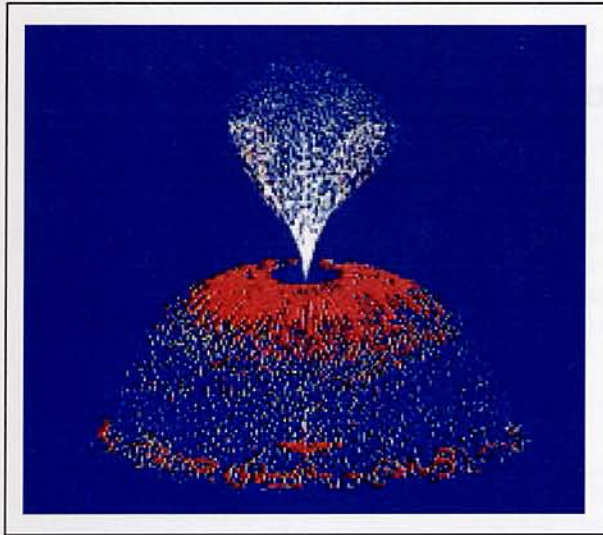
This consists of a large horizontal wheel with three drivers charged with a "white flitter" composition, three gerbes fixed evenly around the periphery and point slightly upward, charged with "Niagara Falls" composition, and a vertical gerbe fixed in the center, charged with titanium. The "Niagara Falls" gerbes should not be choked with clay but left open. Mean powder may be added to the drivers if necessary to make the wheel revolve at a medium speed. All seven cases are matched to fire at the same time. The piece produces a most striking display. Refer to table L-103-1 for composition formulas.

Table L-103B-1 Snowstorm wheel compositions

White Flitter		Niagara Falls		Gerbe	
Potassium Nitrate	17	Potassium Perchlorate	4	Potassium Nitrate	6
Sulfur, flour	3	Aluminum, medium fine	1	Sulfur, flour	1
Charcoal, dust	3	Aluminum, medium	1/2	Charcoal, dust	1
Antimony, Chinese needle	11	Aluminum, flitters	1/2	Titanium, coarse	3
Aluminum, medium fine	10	Red Gum	1		
Aluminum, flitters	3				

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PART II (HORIZONTAL)
EXHIBITION WHEELS AND REVOLVING PIECES

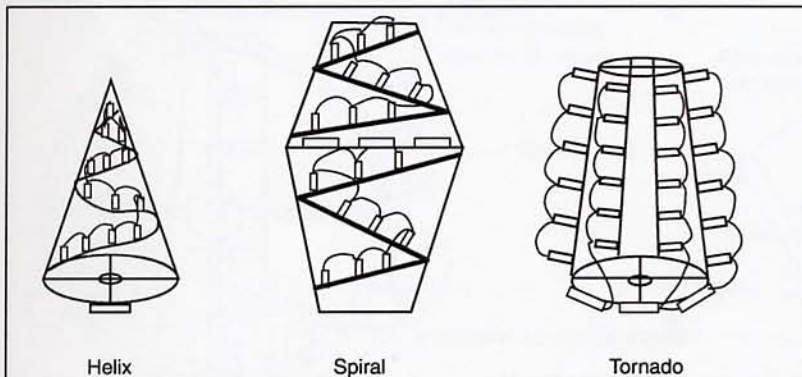
Figure L-103B-5 Snowstorm Wheel



I. Spiral, Helix and Tornado Wheels

These consist of wheels which have four light supports attached so the form a cone. Around these supports are wound thin strips of wood bamboo or rattan to form a spiral. To these strips are attached lances which burn along with the drivers forming a very beautiful effect. For "tornado wheels", spiral rattan is not used and the lances are attached directly to the supports.

Figure L-103B-6 Spiral, Helix, and Tornado Wheels



J. Carousel Wheel

These are constructed similarly to the Butterfly wheel, except all three drivers burn at once. They are loaded with less meal powder and more metal filings. The three small vertical wheels (or saxons) have a colored pot, each of a different color, and all of these burn along with the drivers, making a very spectacular effect.

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EXHIBITION WHEELS AND REVOLVING PIECES PART III (AERIAL) (L-103C)

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(L-103C)
PART III (AERIAL)
EXHIBITION WHEELS AND REVOLVING PIECES

I. INTRODUCTION

The wheels that comprise this series are, without a doubt, the most spectacular revolving pieces that can be made. Perhaps they are the most spectacular of any type of fireworks. They are not often seen nowadays simply because they take much time, care, and patience to construct, and must also have a large area from which to fire them.

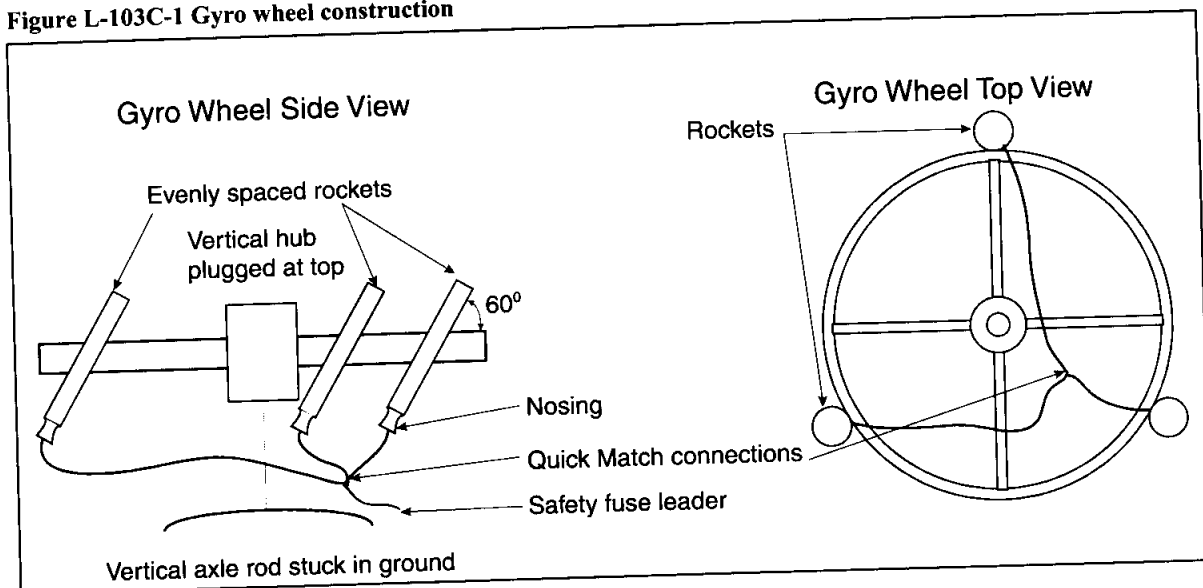
The utmost care must be exercised to have these wheels evenly balanced. If they are just slightly off, they will fly off at an angle and not straight up. Needless to say, this can be very hazardous. All types of aerial wheels must fly straight up. To achieve this, all driver casings must be the same size and each driver have the same weighed amount of clay and composition. All rocket casings must be the same size and have the same weighed amount of clay and composition in each. All quick match connections must be even and as nearly symmetrical and balanced as possible. All garnishments should, balance evenly. When everything is in place the wheel should spin evenly and without, any "heavy spots", when it is placed on a horizontal axis and lightly turned. Strong, light weight wooden wheels should be used. It is very desirable to have wheels for aerial effects ready made or constructed by a professional cabinet maker.

II. PRODUCTS OF MANUFACTURE

A. Gyro Wheels

These are aerial wheels that have rockets to give them both lift and spin. They are generally 6" in diameter and use three 4 oz. rockets. They are usually left ungarnished or end with a salute placed on top of the partially plugged hub. They are quite simple to make, as shown in the diagram. The rockets should be tied or wired evenly around the outside of the rim. They should be placed so they are slanted at about a 60° angle to the wheel rim. The axle should fit well inside the hub so the wheel does not wobble before it ascends. But it should not fit too close so as to impede the spin of the wheel. Refer to figure L-103C-1.

Figure L-103C-1 Gyro wheel construction

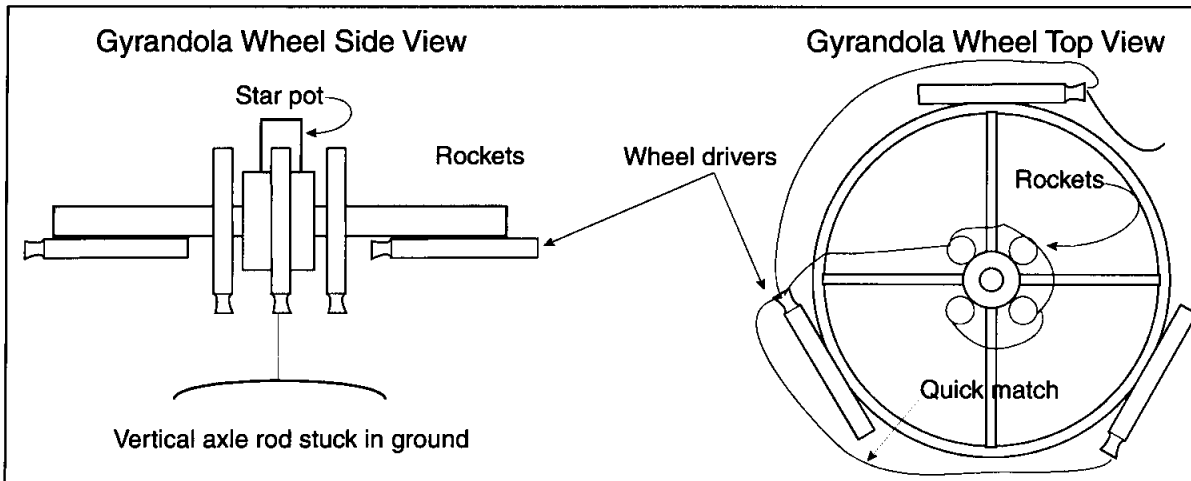


B. Girandola Wheels

These are larger wheels (about 16" in diameter) that have wheel drivers to give spin, and rockets to give lift. Their construction is given in the diagrams. For a 16" wheel use three $1\frac{1}{2}$ " I.D. (4 oz. size) drivers if all three are going to fire at once. Use four $\frac{3}{4}$ " I.D. (1 lb. size) rockets. The number and or size of rockets and drivers may be varied, depending on the size of the wheel, type and weight of garnishment, number of rockets or drivers firing at one time, etc. Refer to figure L-103C-2.

(L-103C)
PART III (AERIAL)
EXHIBITION WHEELS AND REVOLVING PIECES

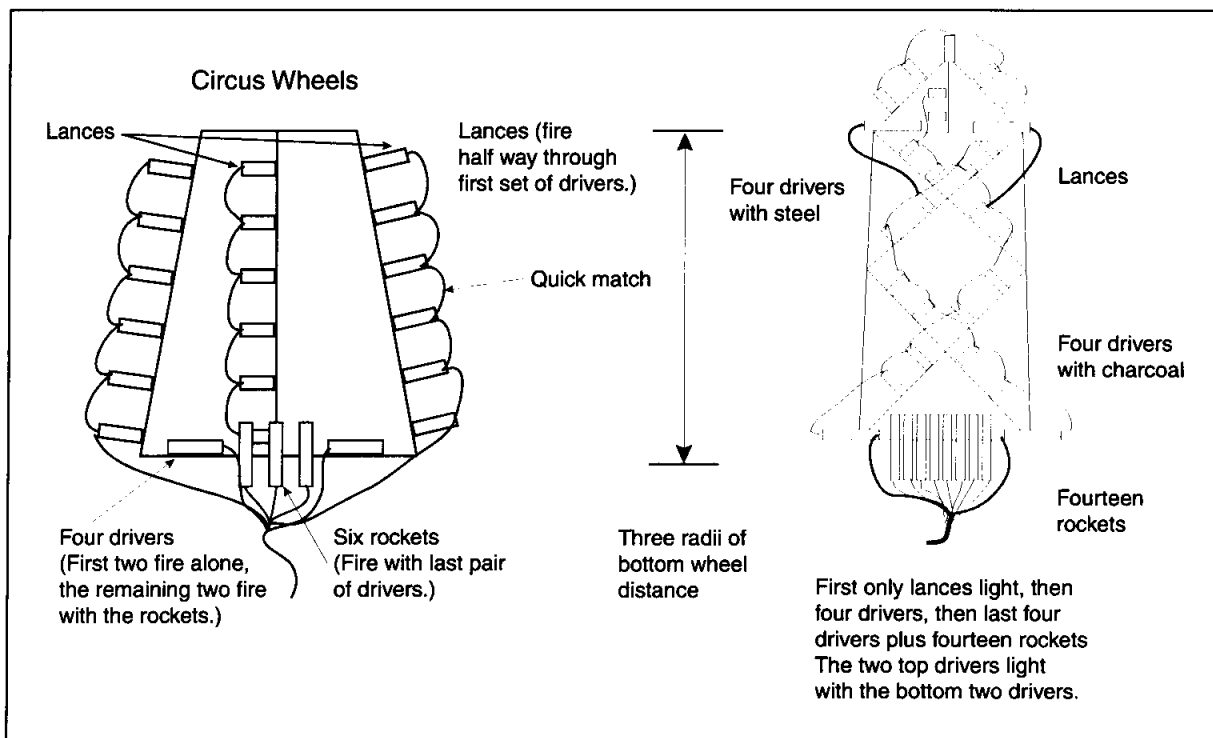
Figure L-103C-2 Gyrandola wheel construction



C. Circus Wheels

These are constructed in the same manner as the Girandola wheels except with larger rockets and turning cases. A light framework is made consisting of four uprights tacked and wired to the rim of the larger bottom wheel and to the rim of a smaller top wheel. Refer to figure L-103C-3.

Figure L-103C-3 Circus wheel construction



BASIC GROUND DISPLAYS (L-104)

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BASIC GROUND DISPLAYS

I. INTRODUCTION

Most of these items may be constructed and displayed with comparative safety. However, there are some items that have more than uncommonly dangerous compositions. Therefore, all safety precautions given must be followed to the letter.

Certain principles and pyrotechnic theory are also included so the pyrotechnist can better understand the processes that are involved in making these fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing qualities, dimensions, are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition nor the casing, nor the ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility. Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. COMPOSITION FORMULAS*

#1 and #2 (White Fire)	#1	#2	#3 (Blue Fire)	#3
Saltpeter	7	8	Potassium Chlorate	8
Sulfur, flour	1	1	Barium Nitrate	7
Antimony Sulfide, black		1	Paris Green	6
Arsenic Sulfide, red	2		Shellac, orange	1
			Stearic Acid	1
			PVC	1/2

#4 (Red Fire)		#5 (Pink Fire)		#6 (Yellow Fire)	
Potassium Chlorate	2	Potassium Perchlorate	4	Potassium Perchlorate	2
Strontium Nitrate	4	Plaster of Paris	1	Barium Nitrate	6
Shellac, orange	1	Shellac, orange	1	Sodium Oxalate	1
				Sulfur, flour	1/2
				Red Gum Yacca	1

#7 (Green Fire)		#8 (Orange Fire)		#9 (Purple Fire)	
Barium Chlorate	9	Potassium Perchlorate	1	Potassium Perchlorate	9
Shellac, orange	2	Strontium Nitrate	6	Strontium Nitrate	7
		Sodium Oxalate	1-1/2	Copper Oxide, black	7
		Shellac	1	Sulfur, flour	5
		Sulfur, flour	1/2	PVC	1/2

* NOTE: All parts are by weight.

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BASIC GROUND DISPLAYS

II. COMPOSITION FORMULAS* continued

#10 (Gerbe/Fountain/Volcano, Gold)		#11 & #12 (Gerbe/Fountain/Volcano, Silver)		
			#11	#12
Saltpeter	6			
Sulfur	1	Potassium Perchlorate		3
Charcoal, dust	1	Potassium Nitrate	6	
Charcoal, coarse	1/2	Sulfur, flour	1	
*Steel Filings	2	Charcoal, dust	1	
*Coated with Paraffin		Aluminum, bright		1-1/2
		Aluminum, flitters		1/2
		Titanium, coarse	3	
		Red Gum Yacca		1/2

#13 (Flower Pot)		#14 (Candle Composition)	
Saltpeter	12	Saltpeter	5
Sulfur flour	5	Sulfur	1
Lampblack	3	Charcoal, 100 mesh	2
Arsenic, Sulfide, red	2	Charcoal, 40 mesh	1/2
		Charcoal, 12-20 mesh	1/2

#15 (Green Stars)		#16 and #17 (Red Stars)		#16	#17
Barium Chlorate	9	Potassium Chlorate	6	6	
Shellac	1	Strontium Nitrate	6		
Dextrin	1/4	Strontium Carbonate			1
		Shellac, orange	1		1
		Charcoal	2		1
		Dextrin	1/2		1/2

#18 (White Stars)	#19 and #20 (Blue Stars)	#19	#20	#21 (Yellow Stars)	
Saltpeter	10	Potassium Chlorate	18	12	Potassium Chlorate 4
Sulfur	3	Paris Green	4	5	Shellac 1
Arsenic Sulfide, red	3	Stearic Acid	2		Charcoal, dust 1
Dextrin	1/2	PVC	1/2	1/2	Barium Nitrate 1-1/2
		Barium Nitrate		4	Sodium Oxalate 1/4
		Shellac, orange		2-1/2	Dextrin 1/4
		Dextrin	1	1/2	

#22 (Purple Stars)		#23 (Silver Stars)		#24 (Italian Streamers)	
Potassium Chlorate	6	Saltpeter	10	Saltpeter	8
Copper Oxide, black.	1	Sulfur	3	Sulfur	2
Strontium Nitrate	1	Arsenic Sulfide, red	3	Lampblack	1/2
PVC	1/4	Aluminum, bright	1	Sodium Oxalate	4
Shellac	1	Red Gum Yacca	1	Dextrin	1/2

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BASIC GROUND DISPLAYS

II. COMPOSITION FORMULAS* continued

#25 (Gold Comet)		#26 (Silver Comet)	
Salt peter	6	Potassium Perchlorate	10
Sulfur	1	Barium Nitrate	2
Charcoal, dust	3	Aluminum, bright	7
Antimony, Chinese needle.	3	Shellac	1
Meal Powder	6		
Dextrin	1/2		

#27 (Red Meteor)		#28 (Green Meteor)		#29 (Blue Meteor)	
Potassium Perchlorate	24	Potassium Perchlorate.	4	Potassium Perchlorate	14
Strontium Nitrate	12	Barium Chlorate	8	Aluminum, bright	6
Aluminum, bright	8	Barium Nitrate	8	Barium, Carbonate	1
Charcoal, dust	1	Aluminum, bright	6	Paris Green	10
Shellac, orange	2	Charcoal, dust	1-1/2	PVC	1
Dextrin, yellow	2	Red Gum Yacca	2	Dextrin, yellow	1
		Dextrin, yellow	1	Shellac, orange	2

#30 (Golden Butterfly)		#31 (Pearl Streamer)	
Potassium Perchlorate	6	Potassium Nitrate	2
Barium Chlorate	4	Charcoal, dust	1
Aluminum, bright	4	Zinc, dust	4
Sodium Oxalate	2	Meal powder	1
Barium Carbonate	1	Dextrin, yellow	1/4
Shellac, orange	2		
Dextrin, yellow	1/2		

***NOTE:** All parts are by weight.

All compositions should be mixed well with 24 mesh mixing sieves and then moisten with a 50:50 mixture of water alcohol. Only practice will tell how much to dampen, but the mixture should have the consistency of bread dough. If the stars are dampened too much, they will not perform properly. If they are dampened too little, they will crumble. Form into pumped or cut stars, dust with meal powder, and dry at least five days in a warm place.

III. PRODUCTS OF MANUFACTURE

Colored Flames

1. Tableau Fire

This is one of the simplest types of fireworks. It consists of merely pouring the composition into a paper can and igniting it with a fuse.

Composition: Any of the composition formulas Numbers 1 through 9.

Casing: A small paper can.

Ignition: Safety fuse.

Manipulation and Procedure: A good tableau fire should burn brightly without sputtering or giving off excessive smoke. To achieve this all ingredients should be especially well mixed, using mixing sieves. Pour the composition in the can and insert a piece of safety fuse.

2. Torches

Composition: Same as above.

Casing: These are merely made by wet-rolling four complete turns of heavy Kraft paper around a former. They may be made any length and diameter.

Ignition: Safety fuse, priming.

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Materials: A wooden handle (if the torch is to be held), or a wooden spike.

Tools: A former with which to roll the case, a funnel, whose spout will fit inside the case, a wooden dowel that is about 1/4" smaller in diameter than the funnel spout and about 12" longer than the case.

Manipulation and Procedure: Stand the case upright on a solid support (floor, table) and insert the spout of the funnel. Now drop the dowel through the spout and case until it also rests on the support. Fill the funnel with composition, and, steadying the funnel with one hand, grasp the rod firmly with the other, raising it about 6". Drive it with a firm stroke up and down as the composition runs into the case. Continue until the case is filled up to the bottom of the funnel spout. When this is withdrawn, the space remaining is for the wooden spike or handle to be inserted, using a little glue. Wrap the outside with a few turns of paper, leaving enough for a nosing. Prime, insert the fuse and twist the nosing around the fuse.

B. Sprays and Showers.

These are all variations of the same principle which is a casing rammed solid with a composition that gives a shower or spray of sparks and fire.

1. Fountains.

There are different forms of fountains. The first type is a hand fountain which has a wooden handle glued in one end of the casing. The second is the spike fountain which has a wooden spike in place of the handle, and is stuck in the ground. The last type is the base fountain. This consists of a wooden block to which the casing is cemented, generally in a vertical position. The hand fountains are the smallest, the base next, and the spike, the largest.

Compositions: Numbers #10, #11, or #12. Meal powder may be added to give extra high sprays.

Casings: Almost any size casing will do but the nozzle diameter must be 1/3 the I. D. or less. They should be wet-rolled.

Ignition: Match, priming.

Materials: Wooden handle, spike, or base, Professional Pyro. Adhesive.

Tools: A ramming base described as follows: Drill a hole the same diameter case and 3/8" deep in a block of wood at least 1-1/2" square and 1/2" thick. Insert and glue in place a piece of wooden dowel 1/2" long. When the glue is well dried, drill a hole in the center of this dowel 3/8" deep x 1/3 the I. D. of the casing. Insert in this hole a dowel cut so that it protrudes above the surface of the larger dowel the length of 1/2 I. D. of the casing. Two rammers both 1" longer than the casing and of the same I. D. One should have a hole drilled in one end such that the rammer can fit over the smaller of the two dowels of the ramming base. Tools made from aluminum can also be constructed and are greatly preferable. A mallet, preferably of rawhide, and a scoop for measuring composition and clay are also needed.

Manipulations and Procedure: Slip the casing over the ramming base and, using the rammer with the hole, drive a scoop full of clay in it with ten good blows to form a plug 1/2 I. D. thick. As always, the clay should be poured in all at once. Now drive a scoop full of composition with ten good blows. The scoop should hold just enough composition so that when it is driven it rises 1/2" within the casing. Continue driving composition until it has come to within one I. D. of the top of the casing. This space is for the wooden handle or spike. (The composition may be driven all the way to the top for a base fountain.) Prime the fuse hole cavity well, and insert a fuse. When the priming is dry, the article may be nosed and the spike etc., attached with professional pyro adhesive. If desired, the base or spike, but not hand fountains may be made so they finish with a "bounce" or report. This is done by putting a 1/4 oz. of black powder after the last charge of composition and before the clay. The larger (3/4" or more) base and spike fountains may also be greatly enhanced by adding a few cut stars that do not contain any Chlorate to the charges of composition when containing These are called "jeweled", "Prismatic", or "floral" fountains.

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Compositions that contain steel or iron filings are more difficult to ignite. Therefore, be sure and fill the nozzle hole full of priming. The filings are also quickly oxidized by the saltpeter, causing the fountains to become quite hot and destroying the usefulness of the filings. To prevent this, the filings must be coated with paraffin so the saltpeter cannot reach them. The easiest way to do this is to melt some paraffin in a shallow pan as hot as possible without permitting it to smoke. To this add as many of the filings as the paraffin will completely coat. There should be no excess paraffin, but just enough to completely cover each filing. Shake the pan and stir frequently while cooling to prevent the filings from caking. Titanium does not need to be treated.

2. Volcanoes

These have the same effect as fountains but they are made using stout cones instead of tubes.

Composition: Same as above. No meal powder is added.

Casing: A paper cone similar to the ones on which thread or twine is wrapped. It should have an opening at its tip of about 1/8". Cones made especially for volcanoes may be obtained from Westech.

Ignition: Safety fuse, priming.

Materials: Professional pyro adhesive 1/8" chipboard, Sodium Silicate (syrupey).

Tools: A pair of rammers made of wood but preferably of aluminum. One is 1/2" diameter and the other is 1-1/4" diameter. Both are about 3" longer than the height of the cone. A ramming mold to hold the cone while it is being rammed. This is made from a block of wood, into which a tapering hole, of the same taper as the cone, is worked. It should be deep enough to accommodate the cone for about one-half of its height.

Manipulation and Procedure: Dip the nose of the cone into a hot Sodium Silicate solution to a depth of about 1" for about one minute and allow to dry. This is to fireproof and reinforce the vent. Place the cone in its mold, prime from the inside so the vent is covered, then ram in small amounts of the composition, moistened slightly with alcohol. This is to allow better consolidation of the composition. Alcohol is used since it will evaporate faster than water. The 1/2" rammer is used till *the cone* is about one-half full. Punch a disc from the chipboard with a diameter equal to the diameter of the cone at the height of the composition. Coat the inside of the cone at this *height with* Professional pyro adhesive and push in the disc. The disc must be very tight and secure, otherwise it will blow out the bottom. (For this same reason the composition must be moistened and rammed very solidly.) Finally insert a piece of safety fuse and wrap with bright paper.

A very amusing variation of the volcano is a "Piping Pyramid" or "Musical Cone. These are made as above except the nose of the cone must be clipped off to allow for the insertions of the whistle tube. The whistle casing itself should be 3" long x 5/16" I. D. x 1/2" O. D. It must be rolled from a smooth type of paper such as the type used in postcards. A rough paper will affect the whistle tone adversely. Kraft and Manila papers may be used with almost as good results. The clipped cone should have been previously dipped in the Silicate, as before. The ramming mold must have a hole in its bottom to allow for the whistle. Fill as before. Instructions for making a whistle will be found under "Calliope Comets".

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3. Flower Pots

These provide remarkable and unusual coruscation's, very different from other types of showers. They are made exactly like hand fountains. The composition #13 requires very careful mixing, otherwise no effect is produced. Use a 24 mesh-mixing sieve.

4. Gerbes

These are merely fountains that are wired to a set piece rather than stuck in the ground. They are made exactly like fountains except no wooden spike, etc. is attached.

5. Cascades (Niagara Falls)

These are similar to fountains except unchoked cases are used and they are suspended from a wire so the fire falls downward rather than being shot upward from the ground. Refer to figure L-104-1

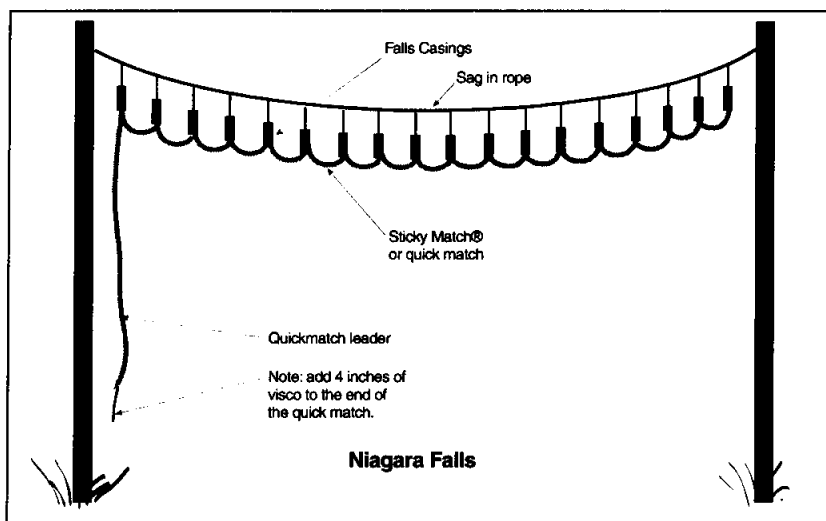
Composition: #12 is most often used. #10 or #11 may also be used.

Casings: Any size may be used. The more there are and the larger they are, the better the effect. They are tied to a rope from 6" to 15" apart, depending upon the size used. The larger they are, and the further apart they are placed. The rope should be tied just *high enough* above the ground so the cascade is just able to reach it. Only experimentation will indicate how close together the cases should be tied and how *high above* the ground they should be placed. A set of 1-1/4" I.D. casings is used for exhibition work and is tied about 50' above the ground, the arc of the suspended rope giving just the right perspective.

Tools: Same as for fountains.

Manipulation and Procedure: Same as for fountains except no clay is used. The casings should only have composition in them. Prime all cavities made by the ramming base nipple, nose and connect all together with quick match.

Figure L-104-1 Niagara Falls



C. Roman Candles

Roman candies are very popular. Contrary to general opinion, skill and experience are required to make really good candles. The principle on which the Roman candle is constructed is as follows. At the bottom of the case is a plug of clay. On top of this is a small amount of grain powder (FFFFg rifle powder). On top of this powder is a pierced, cylindrical star, which just comfortably slides down the tube. Surrounding and on top of the star is a slow-burning powder called "candle comp." The grain powder, star, and candle comp sequence is repeated until the tube is filled, and functions thus-the comp burns like a fountain with luminous sparks, and upon reaching the star, ignites it and flashes around it and through its cavity to fire the blowing (propelling) charge of grain powder. The blowing charge also ignites the next layer of candle comp. and the effect is repeated. The fit of the stars in the tube must be just right. If they are too loose, they will merely pop out of the top and land on the ground burning; if they are too tight, they will be shot out with such force that they will blow themselves out. The candle comp. must fit

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snugly around the stars and also be firmly rammed down on top of them, otherwise the stars will come out like machine gun bullets. The amount of grain powder varies with the position of the star, smaller amounts being used at the lower portion of the case. This is done so the stars may rise to approximately the same height; the charge at the bottom acting through a greater distance and on a firmer surface, naturally acts more effectively and less is required.

1. Regular.

Compositions: #14, and any, or all, of the star formulas #15 - #23.

Casings: These should be wet-rolled from a good quality paper (Kraft, or chipboard Manila, chipboard). The I. D. may vary from 5/16" to 1/2", but 3/8" is most often used. The O.D. should be at least 1-1/2 times the I.D., preferably more. The ideal size is 3/8" I. D. x 3/4" O. D. x 15" long. This will hold 8 to 10 balls (stars).

Ignition: Black Match, priming.

Materials: FFFFg black rifle powder; dry, powdered clay.

Tools: A rammer which is a rod 1" longer than the casing and slightly less in diameter than the I. D. so it can pass easily up and clown in the candle case. An adjustable powder scoop, it is made just as a 1/4" diameter. regular scoop, except the handle is not fastened but allowed to slide within the shovel part of the scoop. Thus, each powder charge can be easily adjusted using only one scoop. A star pump that is especially adapted for making Roman candle stars. The plunger has in its exact center a rod that is 1/6 the diameter. and equal in length to the star it makes. Thus, it forms a central cavity down the center of the star. A regular scoop for measuring the charges of candle comp and clay.

Manipulation and Procedure: Place the case on a firm foundation, pour in a scoop full of clay and ram very hard, using a rawhide mallet. Remove the rammer and pour in a scoop of gunpowder. (NOTE: the exact amount must be ascertained by experimentation. Adjust the powder scoop so it increases the powder charge for each star. All stars would be blown to the same height-the higher the better. However, if too much powder is used the stars will be shot out with so much force that the flame will be extinguished and they will be "blown blind." Start with about 2-3 grains for the first charge. On top of the powder charge, drop in a star, and then a scoop full of candle composition Ram with about six light blows of the mallet. Remove rammer and pour in another scoop of gunpowder another star, and another scoop of candle comp. Ram as has the desired number of stars. Prime, nose match, and the candle is finished.

2. Exhibition

These are made like the regular candles except cases with a 3/4" I. D. are used. Stars that contain Aluminum (#27 - #29) are generally used instead of the plainer mixings. Casing O.D. Is have the same relation to I.D. The most common length is 15".

3. Italian Streamers

These are made exactly like the exhibition candles except they are loaded with stars made from #24. They leave a beautiful golden tail as they ascend and are one of the most beautiful pieces made.

D. Mines

These are paper mortars (strong paper tubes standing vertically on a wooden base into which it is countersunk and cemented with Professional pyro adhesive.) that shoot into the air a display of stars, serpents, etc. They are often equipped with fountains, Roman candles, etc., which make a display on the ground before the mine itself fires.

1. Prismatic Mines:

Compositions: Any of the star compositions #15 - #23.

Casings: wet-rolling chipboard or other heavy paper around a suitable former makes the mortars for these items. Mailing tubes or other fairly strong paper tubes will give good results. The proportions of a mine do not particularly matter but the wall should be at least 1/32" thick and the height should be at least 2-1/2 times as long as the I. D. Since not much force is generated by the propelling charge of powder on the loosely packed stars, and since they should give a good spread both horizontally as well as vertically, the mortar need not be too strong or high.

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Ignition: Safety fuse.

Materials: Professional pyro adhesive., circular piece of stiff chipboard the same I. D. as the mortar, a wooden block to act as the mortar base (it should be at least 1/2" larger on a side than the O. D. of the mortar), Fg black rifle powder.

Tools: A suitable former (if the mortar is to be hand-rolled).

Manipulation and Procedure: Cement the mortar in the circular groove in the mortar base-with professional pyrotechnic adhesive. Drop in a quantity of stars and Fg powder. For every ounce of stars, use two level teaspoons of blowing powder. The mortar may be filled up to one-half full. Now cut a hole in the center of the circular piece of chipboard just barely large enough so the Roman candle or fountain may be pushed through. The candle or fountain should not have the bottom plug of clay but be left open. The candle should be about 3 balls and the fountain quite short. Push the chipboard disc (with its centrally placed fountain or candle) into the mine until it is about 1" above its contents. Push another disc of chipboard over the candle (or fountain) until it is just inside the mortar and the job is done.

2. Spangle Mines

These are made exactly as above. Rather than shooting regular stars they shoot gold or silver "spangles" (stars that are 3/4" or 1-1/4" in diameter, made from formulas #23 or #24.) A mortar of at least 3" diameter should be used.

3. Meteoric Shower Shells

The ground version is made exactly like a Spangle mine but formulas #26, #27, #28, or #29 are used.

4. Serpent Mines

These are made exactly like Spangle Mines but using serpents or saucissons instead. The larger the I.D. of the mortar, the better.

5. Thunder Mines

Same as above but using firecrackers instead of serpents.

6. Battle Mines

Same except using M-80 type salutes with very short 1/4" fuses.

7. Thunder and Rainbow Mines

Combination of stars and firecrackers. The variety of effects almost unlimited. The imagination of the artificer will suggest other combinations using whistles, grasshoppers, and other items.

E. Comets

These are essentially mines that shoot a single large star to a height of about 150 feet.

1 Plain

This is a paper mortar cemented to wooden base with adhesive. It shoots a large (about 1-1/4" in diameter tailed star to the height of about 150 feet. The star may be either gold or silver. In some circles "comets" are used to designate a star that burns with a charcoal or lampblack (golden) effect; "meteors" are used to designate a star that burns with an aluminum, or "electric" (silver) effect.

Compositions: #25 and #26.

Casings: A paper tube that is attached to a wooden base to act as a mortar. It has the following dimensions: I. D. 1-1/4" x 6" long x 1/16" wall wooden base: 2"x2"x1/2". The tube is attached to the base with Professional Pyrotechnic Adhesive.

Ignition: Safety fuse, priming.

Materials: Professional Pyrotechnic Adhesive, Fg black rifle powder, thin chipboard.

Tools: 1-1/8" star pump, a suitable former 1-1/4" diameter. and about 8" long (if the mortar is to be hand-rolled).

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Manipulation and Procedure: Punch a hole in the mortar about 1/4" from one end and cement this end securely to the wooden base using Adhesive. Allow to dry at least six hours. Pump a large star using a 1-1/8" star pump. Prime one end of the star heavily and allow to dry a couple of days. Weigh the star. The correct amount of driving charge is about 1/5 its weight of Fg black rifle powder. Drop this amount in the mortar and drop in the star on top of it, primed end down. Cut a thin chipboard disc equal to the I. D. of the mortar and push it on top of the star to secure it and the driving charge. Poke a length of safety fuse in the hole at the bottom of the mortar.

2. Fancy

There are many types of fancy comets. Some of these are:

a. Floral

This is the same as above except as the large star reaches its zenith, it bursts into a shower of multi-colored smaller stars. Also called "bursting comets."

Compositions: Same as the above with the addition of some colored stars.

Casings: In order to achieve the floral break, the star itself must be enclosed in a casing. This should be 3-1/4" long x 1/16" wall and made from Kraft or Manila should be wet-rolled around the star the star itself acting as the former. One end of the star must be flush with an end of its casing. The mortar tube is the same as for plain comets.

Ignition Materials, and Tools: same as for Plain Comets

Manipulation and Procedure: Prepare mortar tube as above and roll the star casing as explained above. Since the star has a casing around it, it is really a very large "box star". Being such, it has less area exposed to burn and thus burns slower. It is, therefore, necessary to pump it shorter.) Prime the end of the star that is flush with its casing well. When dry, drop in various colored stars and burst charge on top of the star to within 1/2" of the top. The bursting charge is 1/8 oz. of FFFg black rifle powder. Cut a circle of chipboard with a diameter equal to the I. D. of the star casing and push it in on top of the stars and bursting charge. Secure well with Adhesive and allow to dry. When it is dry, weigh it. The correct amount of driving charge of Fg black powder is about 1/4 to 1/5 the weight of the star. Drop the required amount of driving charge in the mortar and the star on top of this, primed end down. Secure both in the mortar with a circle of thin cardboard, as is the case of plain comets.

b. Thunderbolts

Same as above except the large star explodes with a tremendous flash and, or report. They are made exactly like Floral Comets except instead of a load of stars, they have a charge of salute powder. Before the salute powder can be added, a cardboard disc with a diameter equal to the I. D. of the star casing and a 1/4" hole cut in center is pushed in on top of the star and secured with adhesive. The hole is well primed and the whole is set aside to dry. When dry, fill 3/4 full with salute powder (a fuller load will give a decreased report) and secure the top with another card board disc and adhesive. Do not press this disc down. Salute comp. must be loose in order to give a good report. Weigh to determine amount of driving charge.

c. Calliope

These emit a shrill whistle as they ascend.

Compositions: Same as for Plain Comets. also, whistle composition.

Casings: Mortar is the same as for Floral. The whistle is made with the following dimensions: 5/16" I. D. x 1/2" O. D. x 2" long. Use Kraft or Manila paper and wet-roll. The star is enclosed in a casing 1 1/8" I. D. x 1-3/4" long x 1/16" wall, also wet-rolled.

Ignition and Material: Same as for Plain Comets.

Tools: Same as for Plain Comets in addition to the following: A dowel 3/8" diameter and 2 inches long, a dowel 1-1/8" diameter, x 2-1/2" long, a dowel 5/16" diameter x 5" long, a special whistle ramming base described as follows: Drill a hole 5/16" diameter x 1/4" deep in the center of a block of wood at least 2" square and 1/2" thick; insert and glue in place a wooden dowel 5/16" diameter x 1-1/4" long (cut from 5" piece).

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Manipulation and Procedure: Construct the mortar as before with the same dimensions of a Floral comet. Wet roll the star casing using the 1-1/8" dowel as a former. The whistle casing is charged with composition using the ramming base described above. Ram the whistle composition into the case, using small quantities until the composition is 1/4" from the top. Ram it very tightly, as the composition has to withstand the pressure of the lifting charge without blowing through. Use adequate precaution when doing this. (Use the remainder of the 5/16" diameter dowel for the former and rammer). The 1" vacancy made by the ramming board in the whistle is necessary for the proper production of the sound. Place the star casing on a piece of newspaper. While holding the whistle casing (the 1" vacancy end down) in the center of the star casing, press damp star composition around the whistle using the 3/8" dowel as a rammer. Continue until the composition is 1/4" from the top. Be Sure that this composition is rammed very tightly around the whistle. Cut a piece of light chipboard with a diameter equal to the I. D. of the star casing. Cut a hole in the center of it 1/2" in diameter. Press it over the star composition, the whistle sticking through the hole, and secure it well with Adhesive. Allow to dry. Prime the end of the star well and insert two or three lengths of bare match in this end of the whistle (the 1" vacancy end). These not only insure the proper ignition of the whistle, but they take off some of the pressure of the lifting charge. Weigh to determine lifting charge.

d. Rainbow

These change color as they ascend. Great care must be used in choosing the correct order of color changes as certain colors placed with others do not have the desired visual effects.

Compositions: Any of the following formulas: #25 – #29. The proper succession of colors is very important. Green should not be next to white, for there would not be sufficient contrast. And green should not burn after red, for the color of the barium flame appears to one who has been watching the flame of strontium to be a light and uninteresting blue. Some suggested color changes are: green to red to gold, blue to silver to red, green to red, blue to red, green to gold, blue to silver, gold to green to red, green to red to blue to silver, gold to green to red to silver, silver to blue to red to gold.

Casings, Ignition, and materials: Same as for Floral.

Tools: Same as for Floral, plus a 1-1/8" diameter. x 6" wooden dowel.

Manipulation and Procedure: The star casing should be from 1-1/2" to 3" long, depending on how many color changes there are. Each star composition should be rammed into the casing using the 1-1/8" dowel. Prime one end well and set aside to dry. Weigh to determine driving charge. Drop the required amount of driving charge in the mortar, followed by the star. Cut a circle of chipboard equal to the I. D. of the mortar and push it down on top of the star to secure it and the driving charge in the mortar.

e. Combination

In addition, these above effects may be combined into one single comet. For example, there can be a "whistling, bursting comet"; or a "color changing thunderbolt", etc. Use your own ingenuity and imagination in devising your own creations using the above principles.

f. Golden Butterfly Shells

This consists of a paper mortar cemented to a wooden base. It projects a large star of intense brilliancy high into the air, leaving a beautiful shimmering, fluttering trail as it ascends.

Composition: Formula #30.

Casing, Materials, Tools, Manipulation and Procedure: are the same as for "plain comets".

g. Pearl Streamer Shells

Same as above except a beautiful pearl blue-white streamer is left as the Star ascends.

Composition: Formula #31.

Casing, Materials, Tools, Manipulation and Procedure: are the same as for "plain comets".

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EXHIBITION GROUND DISPLAYS PART I (TEMPLE PIECES) (L-104A)

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(L-104A)
PART I (TEMPLE PIECES)
EXHIBITION GROUND DISPLAYS

I. INTRODUCTION

The pieces that make up this division are various ensembles of the basic ground displays. They provide a very entertaining and varied "displayette" by themselves and should be viewed at fairly close range. They are, therefore, highly successful for backyard, private, or country club-type displays. None of these types of displays could be complete without a large variety of these items.

Temple pieces of all types are fairly easy to assemble, and the pyrotechnist should have no trouble inventing his own creations. Those given here are those that have proven to be favorites for many years, or the author's own creations. All of the safety precautions, formulas, etc., given in L-104 should be observed and applied.

Temple pieces provide the pyrotechnist an opportunity for his imagination to run wild, both in deciding the combinations of effects, and in naming them. The displays may be as desired, but do not allow more than two different visual effects to be happening at once, otherwise mass confusion results. Different effects may follow each other at short intervals but allow sufficient delay between them to allow each to be appreciated and savored.

A. Candle Batteries

The various types of batteries consist of grouping together a large number of Roman candles that fire simultaneously. They form a very effective piece of fireworks and are always one of the highlights of a display. The more candles used, the more effective the display. Generally 10 ball candles are used fit all types of batteries.

1. Regular Candle Battery

This piece is made by taking a box about 2" higher than the candles to be used and filling it with as many candles as it will hold. The space above the candles in the box is filled with pieces of black match. A piece of cardboard should be placed over the top until it is ready for use. When ready to fire, remove the cardboard, drape a long piece of black match over the side of the box and into the pieces of match and light the other end. Refer to figure L104A-1A

2. Union Battery

This consists of three batteries of candles arranged as shown in figure L104A-1D, one battery having red stars, the center white stars, and the other blue stars.

3. Bengola Battery

This consists of a short colored torch backed up by a fall of candles. When a row of these is fired simultaneously, a very effective display is produced. Refer to figure L104A-1B.

4. Bombette Battery

This is an effective combination of candles and floral shells (see L-105) packed in a box as shown in figure L104A-1E. All candles are lighted by pieces of match in the top, but the floral shells are matched as shown in figure L104A-2F, so they fire one at a time during the burning of the candles.

5. Comet Battery

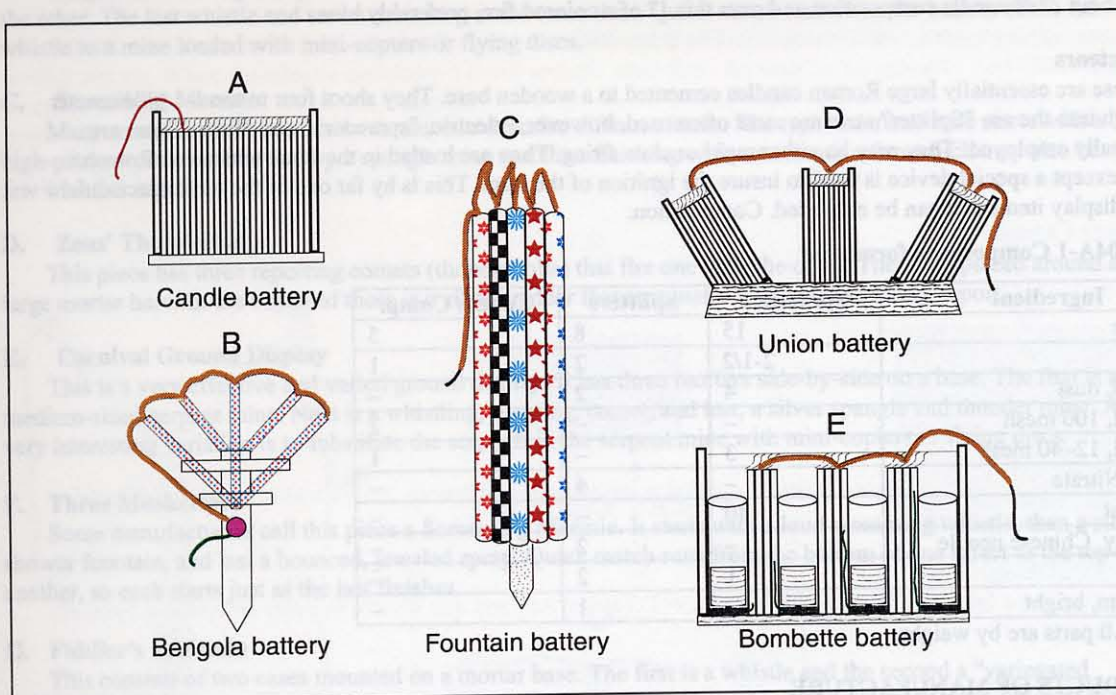
This is the same as above except comet shells are substituted for the floral shells.

6. Fountain Battery

This is made by wrapping 8 to 10 candles around a central spiked fountain or flower pot. All are matched together so there is a continuous fusillade of stars together with the shower of the fountain. A row of 3 or 4 firing simultaneously is very effective. Refer to figure L104A-1C.

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PART I (TEMPLE PIECES)
EXHIBITION GROUND DISPLAYS

Figure L104A-1 Candle batteries



B. Devil Among the Tailors

These are made by taking a mine casing about four inches in diameter and loading it about half full with serpents and grasshoppers. Besides the central candle for firing it, there are four candles tied around the outside of the mortar, and matched to burn at the same time. The candles should hold about three balls each. Refer to figure L104A-3

Figure L104A-2 Bombettes

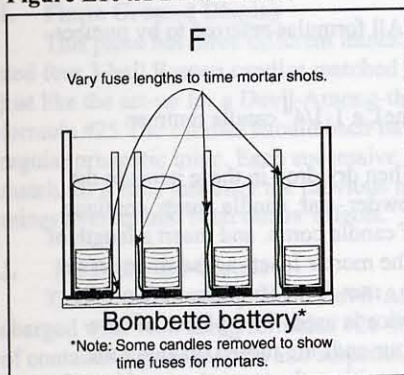
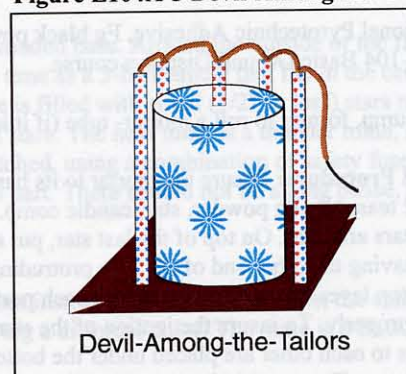


Figure L104A-3 Devil-Among-the Tailors



C. Jack-in-the-Box

This is the same type and size mine as above but instead of the candles, a central golden shower fountain is used. Neither the candles or the fountain should have the lower plug of clay.

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D. Aerolites

These are made by placing a gold comet star at the bottom of a mortar with a blowing charge. Over the star is placed about 2" of candle composition and over this 1" of a colored fire, preferably blue.

E. Meteors

These are essentially large Roman candles cemented to a wooden base. They shoot four to ten 1-1/8" diameter stars high into the air. "Splitter" stars are most often used, however, "electric," "spreader," and "flitter" stars are occasionally employed. They may be either rapid or slow firing. They are loaded in the same manner as Roman candles except a special device is used to insure the ignition of the stars. This is by far one of the most spectacular ground display items that can be exhibited. Composition:

Table 104A-1 Composition formulas*

Ingredient	Spreaders	Splitters	Candle Comp.
Saltpeter	15	8	5
Sulfur	2-1/2	2	1
Charcoal, dust	4	2	-
Charcoal, 100 mesh	-	-	2
Charcoal, 12-40 mesh	3	-	1
Barium Nitrate	-	4	-
Zinc, dust	40	-	-
Antimony, Chinese needle	-	2	-
Dextrin	1	2	-
Aluminum, bright	-	1	-

*Note: All parts are by weight.

II. PRODUCTS OF MANUFACTURE

Casings: A long, strong paper tube is needed for the mortar. It varies in length, depending on the number of stars used. It should be 1-1/4" I.D. and at least 1-3/4" O.D. It is cemented to a wooden base with adhesive. The size of the base depends on the length of the tube. It should be large enough to give the mortar tube an ample foundation.

Ignition: Safety fuse.

Materials: Professional Pyrotechnic Adhesive, Fg black powder, black match. All formulas referred to by number are located in the L-104 Basic Ground Displays course.

Tools: 1-1/8" star pump, former to roll a mortar- tube (if it is to be rolled at home), a 1-1/4" candle rammer.

Manipulations and Procedure: Secure the mortar to its base with adhesive. When dry drop in these items in the following order: 1/2 teaspoon Fg powder, star, candle comp. 1/2 teaspoon Fg powder, star, candle comp; continue this order until all stars are used. On top of the last star, put a double quantity of candle comp. and insert a length of safety fuse in this, having the other end of the fuse protruding out of the top of the mortar. Insert a wad of paper to secure the fuse and top layer of candle comp. After each portion of candle comp., ram firmly to make sure all the contents are seated properly. To insure the ignition of the stars, the following device is used. Two pieces of bare match at right angles to each other are placed under the bottom of the star: the four ends are turned up along the sides of the star and cut off even with the top of it. The match being held in this position, the star is inserted into the top of the mortar and pushed down with the rammer onto the driving charge of gunpowder that has already been introduced. The match at the sides of the star keeps a space open between the star and the walls of the mortar, this space is only partly or loosely filled with candle comp. The bare match acts as quick match, insuring the early ignition of the driving charge as well as the sure ignition of the stars. For a rapid firing, effect, use less candle comp; its amount varies with individual taste, but at least 2 or 3 tablespoonfuls are required for, a rapid fire effect, and more for regular firing.

A. Band-of-Pipers

This is a very effective piece made by attaching three whistling colored meteors around a mortar base and one whistling bursting, comet in the center. The three should use three different formulas such as #27, #28, #29, and in the center one use #25. All four should be matched so as soon as the previous meteor finishes the next fires.

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B. Carousel Ground Display

This, consists of a horizontal double action saxon and three different sized whistles matched to burn one after the other. The last whistle and saxon must stop at the same time. Quick match runs from the bottom of the last whistle to a mine loaded with mini-copters or flying discs.

C. Screaming Meemie

Many manufacturers use this same name to describe different items. The type described here starts with a high-pitched whistle, followed by a spangle mine and then finishing with a prismatic mine which may also have a few whistles added.

D. Zeus' Thunderbolts

This piece has three reporting comets (thunderbolts) that fire one after the other. These are placed around a large mortar base. In the center of these is a silver meteor that terminates with an extra heavy report.

E. Carnival Ground Display

This is a very effective and varied ground display. It has three mortars side-by-side on a base. The first is a medium-sized serpent mine. Next is a whistling, bursting, comet, and last, a silver spangle and thunder mine. A very interesting variation is to substitute the serpents in the serpent mine with mini-copters or flying discs.

F. Three Musketeers

Some manufacturers call this piece a Screaming Meemie. It starts with a loud screaming whistle, then a silver shower fountain, and last a bounced, jeweled spray. Quick match runs from the bottom of one effect to the top of another, so each starts just as the last finishes.

G. Fiddler's Fountain

This consists of two cases mounted on a mortar base. The first is a whistle and the second a "variegated fountain" (a fountain that burns first gold and then silver). The two cases should be connected by quick match so they burn simultaneously.

H. Tuneful Tower

This piece has three cases on a base. The first is a bounced gold shower fountain, the middle a whistle, and the third a bounced silver spray. The three are connected by quick match so all burn at the same time

I. Fiesta Ground Display

This piece has three different mines side-by-side on a wooden base. Around the outside of the first mine are tied four 3-ball Roman candles matched to burn at the same time as a 3-ball candle that fits in the center of the mine just like the set-up for a Devil-Among-the-Tailors. The mine is filled with small (1/2" or less) stars made from formula #25. The candles should each have different colored stars. The next mine is a thunder mine, and the last is a regular prismatic mine. Each successive mine should be matched, using a combination of safety fuse and, or quick match, so it fires just after the previous mine has finished its part. There should not be a long pause, nor should the mines overlap into each others' effects.

J. Battle-in-the-Clouds

This is made exactly like a Devil-Among-the-Tailors. But instead of using regular stars, the candles are charged with stars using formulas #26-#29, each candle having a different color. The mine is a Battle Mine instead of containing grasshoppers and serpents.

K. Pandean Pipe Display

This piece is very amusing. It consists of six to eight whistles, ranging in I.D. from 1/4" to 3/4", set side-by-side on a wooden base. They are matched to burn simultaneously. Each whistle is charged with about 2" whistle composition. In back of these whistles is a jeweled fountain.

L. Jubilee Ground Display

This consists of three fountains mounted in a row on a mortar base. The middle is a silver shower and the two outside ones are gold. These should point slightly outward at an angle. All three burn simultaneously and end with a bounce. Care should be taken that all three burn the same length so that all bounce at the same time.

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PART I (TEMPLE PIECES)
EXHIBITION GROUND DISPLAYS

M. Golden Blossom Display

Consists of 3 fountains (the larger the better) mounted on a wooden frame. This is then nailed to a post that is 2-6 feet high, depending on the size of the fountains (shorter fountains being placed closer to the ground). All 3 burn at once and are loaded with formula #10. The two outside ones are pointed slightly towards each side. Refer to figure L104A-4D.

N. Peacock Plume Fan

Also consists of 3 fountains mounted the same way as M. The center is a large golden, heavily jeweled fountain, the two outside silver fountains are somewhat smaller.

O. Fiesta Cascade

Consists of 5 fountains mounted on a wooden frame. The center points straight up, the two on each side point towards the side. All burn at once. Any composition may be used, and they may be bounced or not.

P. Fiery Cross

Consists of 4 gerbes, mounted is shown. All burn at once. The piece should be placed 6-12 feet above the ground. It makes a very spectacular item. Refer to figure L104A-4A.

Q. Fiery Echo

Consists of 3 fountains and one whistle mounted in a row on a mortar base. All burn at once. Any composition May be used in any fountain

R. Mount Melody

Consists of two fountains loaded with formula #13 (Flower Pot) and one whistle in a row on a mortar base. All burn at once.

S. Bazooka Battery

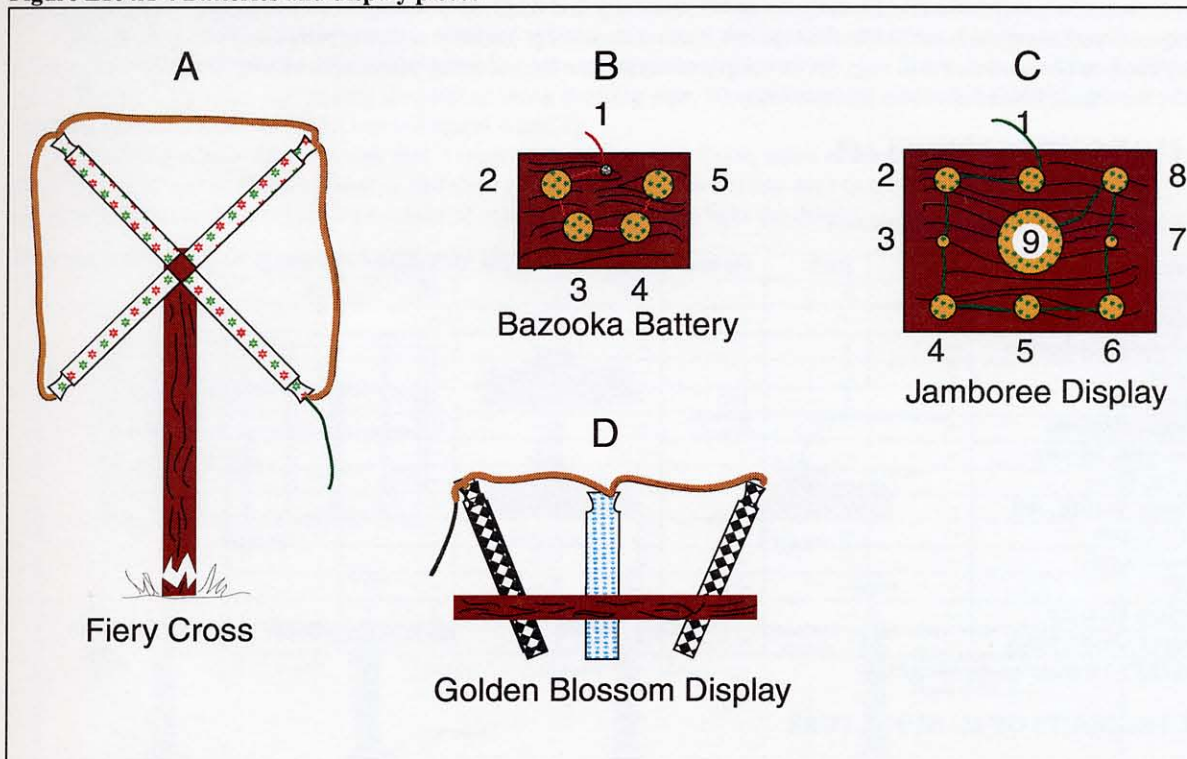
Consists of a battery of various types of comets plus a whistle. First, the whistle fires. This is connected by a short piece of safety fuse to a golden comet: this, in turn, is connected by another short piece of safety fuse to a silver comet: then a floral comet: and last, a thunderbolt. All comets should fire just as the previous one finishes its effect The whistle may burn as long as desired. Precise cutting of the short time delay safety fuse pieces will make this a very effective display. The arrangement of the mortars on their base is shown as they appear from above. Refer to figure L104A-4B.

(L-104A)
PART I (TEMPLE PIECES)
EXHIBITION GROUND DISPLAYS

T. Jamboree Display

Consists of whistles, fountains, comets, and mines, nine tubes in all. First, a golden fountain fires; after a few seconds, a golden comet fires, immediately followed by a whistle and then immediately by a silver comet. After a few seconds delay, a silver fountain fires; a few more seconds and a colored meteor followed immediately by another whistle. When the whistle concludes a small spangle mine fires. As soon as the spangles burn out, a large prismatic and thunder mine finishes the display. A combination of quick match and safety fuse is needed for a correct firing sequence. The arrangement of the mortars is shown below. Refer to figure L104A-4C.

Figure L104A-4 Batteries and display pieces



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EXHIBITION GROUND DISPLAYS PART II (LANCE WORK) (L-104B)

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(L-104B)
EXHIBITION GROUND DISPLAYS
PART II (LANCE WORK)

I. INTRODUCTION

This part of pyrotechnics consists of using "lances" to reproduce various designs letters, portraits, etc. "Lances" are thin paper tubes from 1/4" to 3/8" in diameter and from 2" to 4" long, filled with colored fire composition.

Compositions for lances should burn clearly for about 1 minute, without flaring or clogging. All colors should burn the same length of time, so some of the slower burning compositions (for example, blue) must be not as firmly consolidated. Time each composition in the same size case to determine burning time. If a lance burns to one side, it is because the composition is not well mixed. Mix carefully and thoroughly, using 24 mesh mixing sieves. If a composition chokes and burns down the side it is because it contains too little carbonaceous materials. A little lampblack or charcoal dust will help. In very damp climates, use the red composition with strontium carbonate. Refer to table L-104B-1 for lance compositions.

II. COMPOSITION FORMULAS*

Table L-104B-1 Lance compositions

Materials*	Red	Red	Green	Blue	White	Yellow	Purple
Potassium Chlorate	6	6	—	16	—	16	18
Strontium Nitrate	6	—	—	—	—	—	3
Strontium Carbonate	—	1	—	—	—	—	—
Shellac	2	2	1	—	2	3	2
Lampblack	1	1	1/2	—	—	1/2	—
Barium Chlorate	—	—	9	—	—	—	—
Potassium Nitrate	—	—	—	—	8	—	—
Sulfur, flour	—	—	—	—	2	—	—
Arsenic Sulfide, red	—	—	—	—	1	—	—
Paris Green	—	—	—	5	—	—	—
Stearic Acid	—	—	—	2	—	—	—
PVC	—	—	—	1/2	—	—	1
Sodium Oxalate	—	—	—	—	—	2	—
Copper Oxide, black	—	—	—	—	—	—	3

*NOTE: All parts are by weight.

III. PRODUCTS OF MANUFACTURE

Casings: Generally, the greater the diameter of a lance, the shorter the length may be. Usually, a lance case of 5/16" in diameter, x 4" long, is used. They are made from dry-rolling a good quality paper (Kraft or Manila) three complete turns around a suitable former.

Ignition: Quick match, priming

Materials: Prof. Pyro. Adhesive. and as many frames as necessary. The frames are made in any convenient size from light lumber with outer strips 1/2 x 2" and center strips 1/2" x 1", spaced 1 foot apart each way. Refer to drawing L104B-1, Figure 1. Use bamboo or rattan for the curves. Use light strips of wood for the straight lines that are then tacked on in the outline of the design, letters, etc. (Figure 2). Drive 1" "double pointed" nails to a depth of 1/2" (Figure 3) at intervals of 2-1/2" in the curves and 4" on the straight lines all over the design.

Tools: A former of any convenient length and diameter to roll the lance cases. A funnel and rod to charge the cases with composition. The funnel may be made from a piece of thin aluminum. It is about 2-1/2" on top, 2-1/2" high, with a 3/4" shoulder on the bottom and a 1/4" O.D. spout projecting from the bottom for 1/4". This, when removed from the lance, leaves just the proper space in the case empty for priming. (This shoulder is not a necessity, but allows for faster work.)

The rod should fit easily through the spout, and be about 12" long. In use, a case is held upright on a firm table. The small end of the funnel, which is half full of composition, is inserted in the top of the case. With the rod moving up and down, striking the bottom firmly each time, the composition becomes rammed with sufficient solidarity.

(L-104B)
EXHIBITION GROUND DISPLAYS
PART II (LANCE WORK)

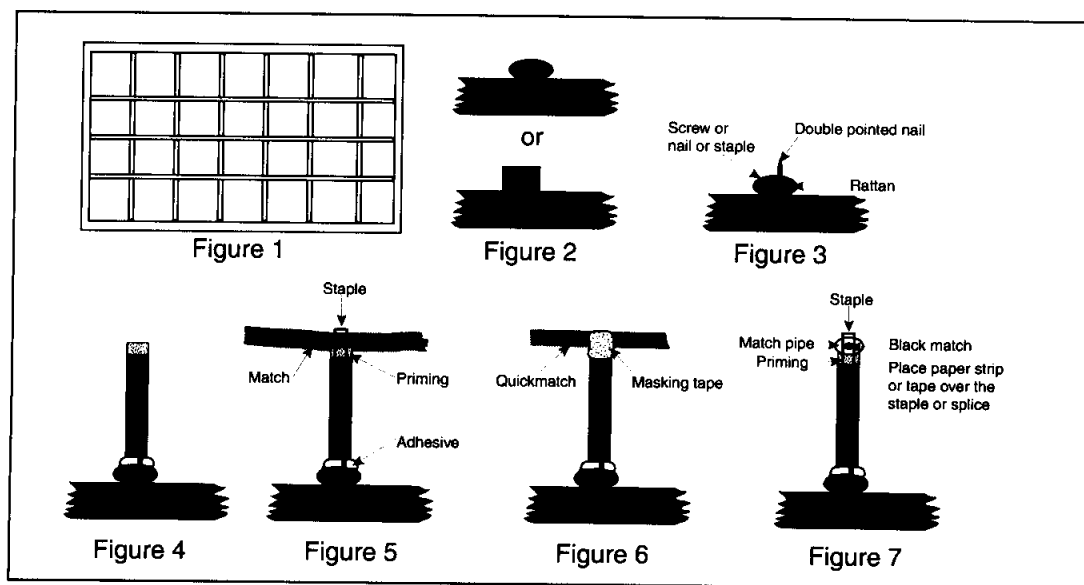
Manipulation and Procedure: When it has been decided what colors are to be used for the various parts of the design, take a handful of lances of the desired color and dip their bottoms into Prof. Pyro. Adhesive to a depth of about 1/8". Then press one onto each of the nails until they are attached firmly to the rattan or stick forming the design (Figure 4).

When the Adhesive has hardened, the frame is ready for matching. Take a length of quick match and, beginning at the upper left corner of the frame, staple it from one lance to another until the entire frame is covered, following the outline of the design as much as possible (Figure 5). The special staple guns available at Westech are ideal for this operation. In the past, it was necessary to pin the match to the lance and then pierce it with all awl. These staple guns, specially made for lance work, do both these operations at once and at a much faster rate.

When the end of a length of match is reached, splice another to it, baring about 2" of the new length and slipping this bare end into the pipe of the preceding. It may be necessary to slit the pipe to accommodate the spliced piece. Secure it by tying and pasting the joint or using masking tape. Now paste a strip about an inch wide (or use masking tape) over the top of the lance (Figures 6 and 7).

When the design is large enough that it requires more than one frame, leave about 2' of match projecting from the lower right corner of each frame so that each can be connected to the one next to it in the final assembly. Also, on one of the bottom frames, leave a leader of match long enough to light the device.

Figure L104B-1 Lance frame and assembly illustrations

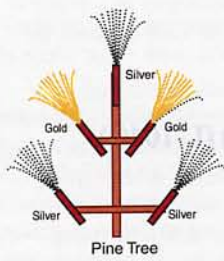


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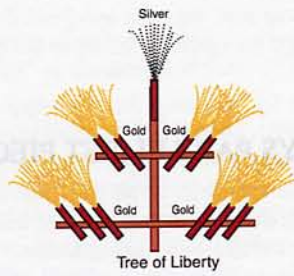
EXHIBITION GROUND DISPLAYS PART III (SET PIECES) (L-104C)

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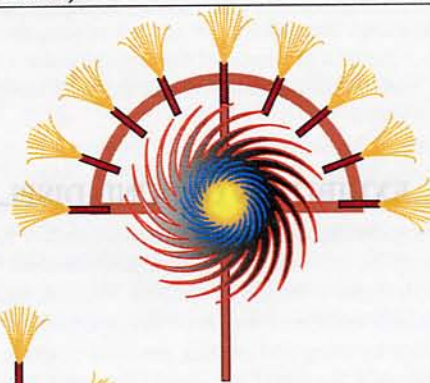
(L-104C)
EXHIBITION GROUND DISPLAYS
PART III (SET PIECES)



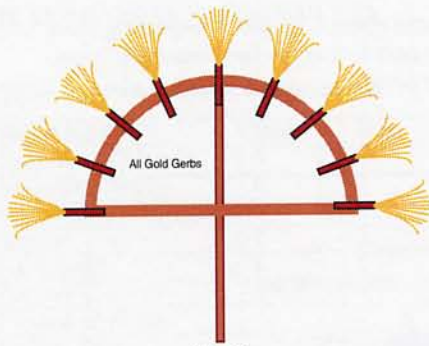
Pine Tree



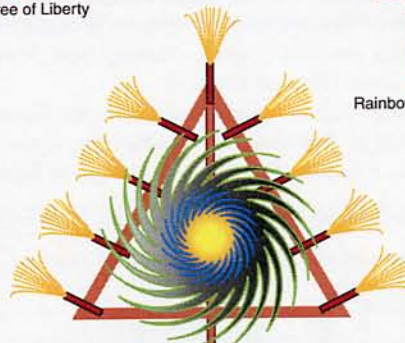
Tree of Liberty



Rainbow Fanfare



Rising Sun



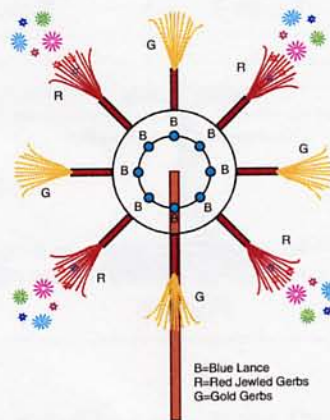
Pyramid



Fountain of Beauty



Rainbow Gardens



Blazing Sun



Golden Sentinel



Pleiades

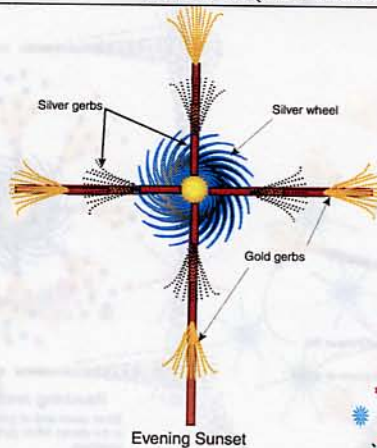
(L-104C)
EXHIBITION GROUND DISPLAYS
PART III (SET PIECES)



Three colored
saxons or
wheels (Gold)

Four gerbs
(Silver)

Turkish Cross

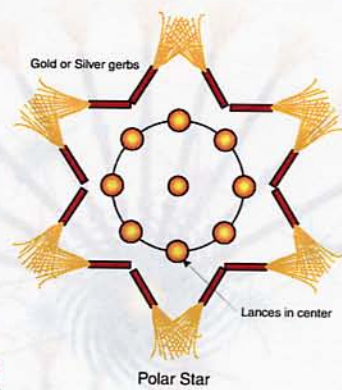


Silver gerbs

Silver wheel

Gold gerbs

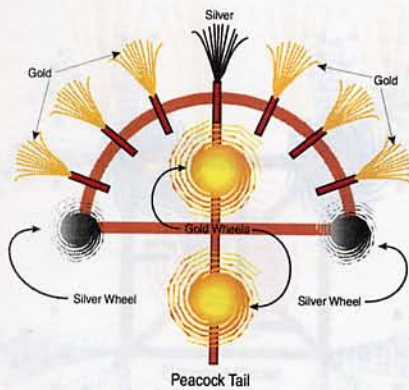
Evening Sunset



Gold or Silver gerbs

Lances in center

Polar Star



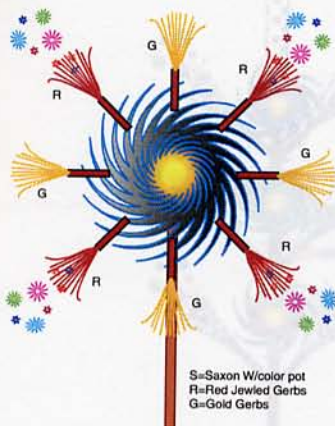
Silver

Gold

Gold

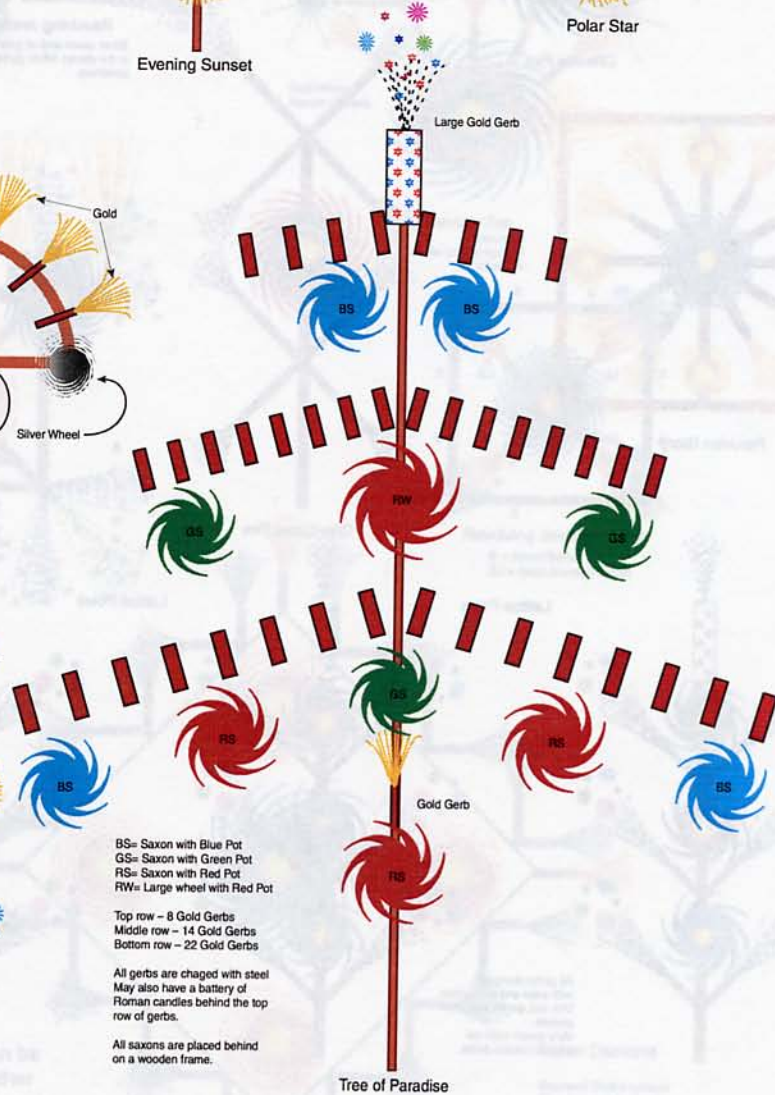
Silver Wheel

Peacock Tail



S=Saxon W/color pot
R=Red Jeweled Gerbs
G=Gold Gerbs

Cluster of Jewels



Large Gold Gerb

Gold Gerb

Tree of Paradise

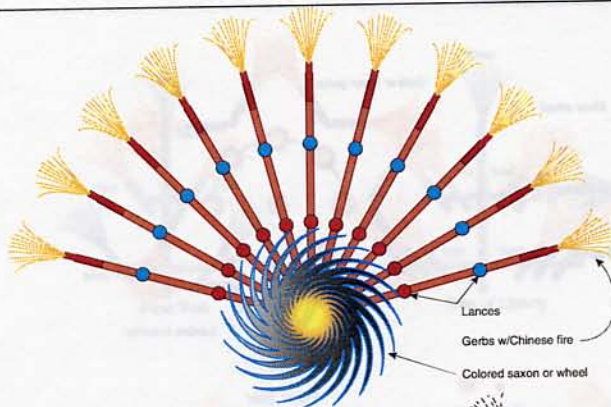
BS= Saxon with Blue Pot
GS= Saxon with Green Pot
RS= Saxon with Red Pot
RW= Large wheel with Red Pot

Top row - 8 Gold Gerbs
Middle row - 14 Gold Gerbs
Bottom row - 22 Gold Gerbs

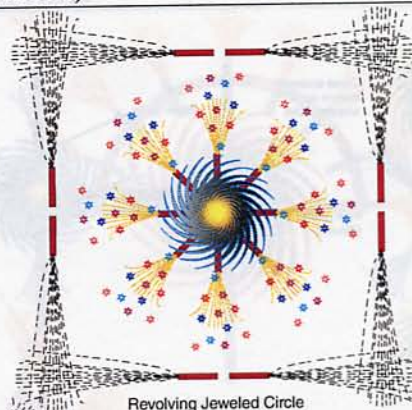
All gerbs are chased with steel
May also have a battery of
Roman candles behind the top
row of gerbs.

All saxons are placed behind
on a wooden frame.

(L-104C)
EXHIBITION GROUND DISPLAYS
PART III (SET PIECES)

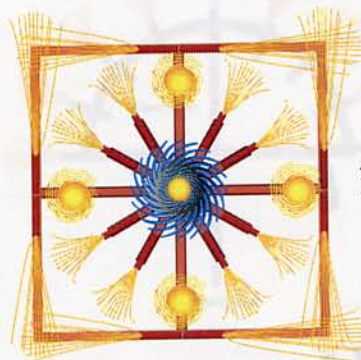


Chinese Fan



Revolving Jeweled Circle

Silver saxon and all gold jeweled gerbs in the center. Silver gerbs around the periphery.

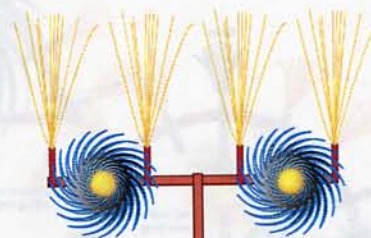


Peruvian Glory

4 Saxons
1 Large central wheel
16 Gerbs



Cross Fire



Gold gerbs
Silver wheels

Golden Glory



Lattice Poles

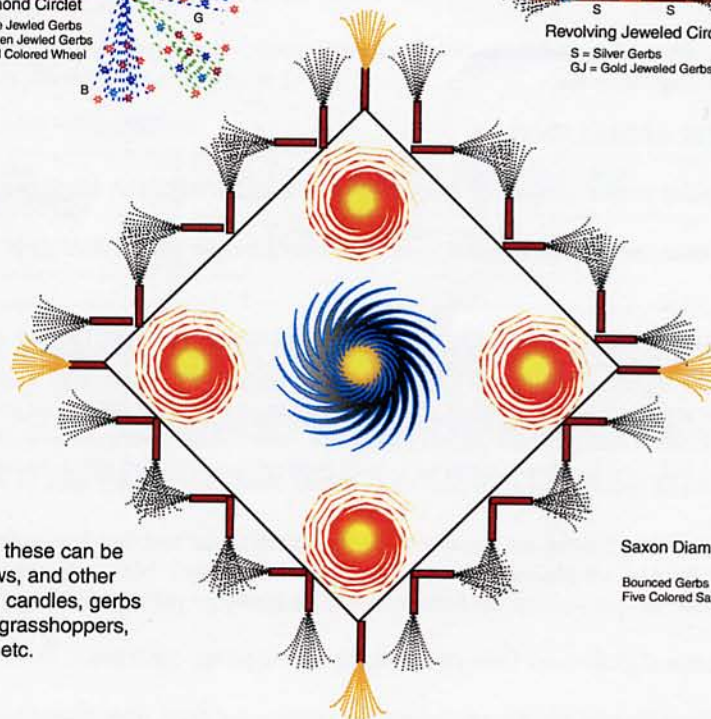
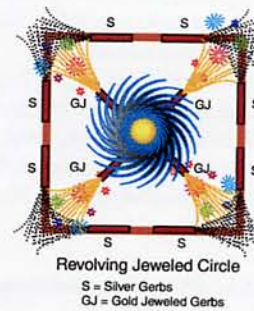
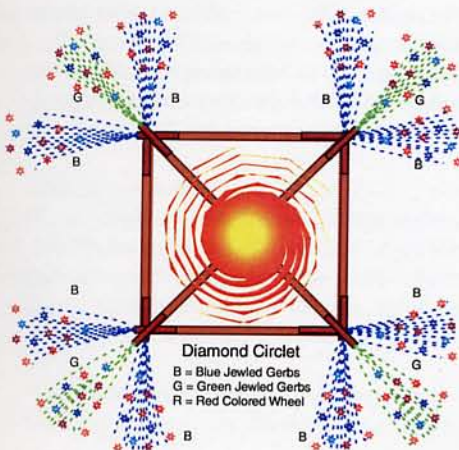
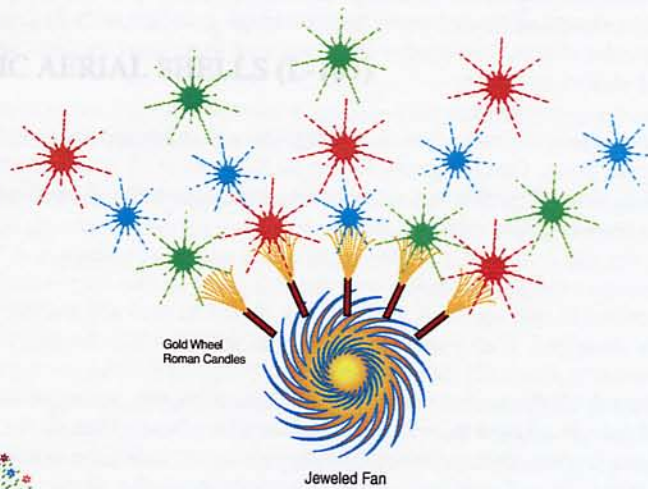
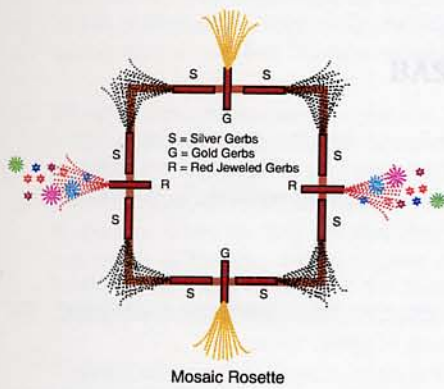


Lattice Poles



All gerbs charged with steel and microstars. Use red, green, and blue saxons. Vary saxon color on adjacent lattice poles.

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EXHIBITION GROUND DISPLAYS
PART III (SET PIECES)



Many other variations of these can be imagined using tiers, rows, and other arrangements of Roman candles, gerbs mines, comets, salutes, grasshoppers, rockets, wheels, lances, etc.

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BASIC AERIAL SHELLS (L-105)

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(L-105)
BASIC AERIAL SHELLS

I. INTRODUCTION

Aerial shells represent the highest development of the pyrotechnic art and require great skill and patience for their successful production. They provide the basis for all pyrotechnic displays. Aerial shells are shot from mortars by means of a charge of black powder and burst high in the air with the production of showers, stars, reports, and other spectacular effects. The smaller shells are shot from paper mortars, the larger ones (3" and more), from commercial steel or iron pipe.

In order to make the construction of these items as enjoyable and as safe as possible, two sets of safety precautions are given. One is a general set to be followed at all times, no matter what type of fireworks are being constructed or fired. The other is a set to be observed especially when firing and displaying aerial shells. All safety precautions must be followed to the letter.

Certain principles and pyrotechnic theory are also given so that the pyrotechnist can better understand the processes that are involved in making aerial shells. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanisms necessary for proper performance are given. Fourth, any special materials (items that neither make up part of the composition nor the casing, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material, since we have no control over the conditions of use. The purchaser and user take full responsibility.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. SAFETY RULES FOR AERIAL SHELLS

1. Always bury the mortars almost completely. Only about 2 or 3 inches should be above ground.
2. NEVER place your hand, arm, or ANY part of your body over a mortar when a shell (is in it even if it is not lit).
3. Keep all shells in boxes or cans (plastic garbage cans with tight lids are best) and sort the various sizes, one size to a container, such as " 3" in one, 4" another, etc.
4. Keep these containers up-wind and at least 15 feet away from the mortars.
5. Mortars should be placed about 4 feet apart with no overhead obstructions of any kind (wires, tree limbs, etc.).
6. Mortars should be loaded by tipping the shells into them with the leader and then letting the shell drop to the bottom. This can be done by not placing the hand directly over the mortar. Make sure the shells go all the way to the bottom. If a shell has not reached the bottom, bounce it gently by pulling and releasing the leader.
7. Mortars should be tilted slightly away from all people (this includes the operator).
8. To prevent mortars from sinking into the ground place a board under them. This should be about 61' wider than each mortar.
9. After firing a few shells, paper may accumulate in the mortars. A stick with a nail in the end can be used to clean them out.

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BASIC AERIAL SHELLS

10. Always check mortars for glowing particles before putting in the next shell.
11. If a shell fails to leave the mortar, never reach in to pull it out (you may lose an arm). Leave it for about five minutes and then if you have to use this pipe, douse it with a pail of water and use your long stick to fish it out. If you have another mortar, leave the shell alone until the display is finished. Bury this shell where it cannot be gotten hold of.
12. Always remember to put the right size shell in the right size mortar. A smaller shell put into a larger mortar will cause the shell to arch out of the mortar and explode on the ground.
13. After the display is over, check the grounds for possible pieces of fireworks that failed to ignite. If a shell failed to explode in the air, find this dud shell at all cost, as another person or child may find it and be severely injured by it. The best way to dispose of this material is to soak it in water and bury it where no one can get it.

III. THEORY AND GENERAL PRINCIPLES

Aerial shells are fired from mortars with a black powder charge, the coarser the better (Fg black rifle powder works well). The amount of this lifting (or driving varies, depending upon the weight, type and size of the shell. This must be determined by experimentation. But a general rule is for every ounce the shell weighs, use 1/5 oz. black rifle powder. Some shells may require more, some less. Only experimentation will give the correct amount for each shell. If other varieties of black powder are used, this quantity may have to be varied. Pyro Powder makes an excellent substitute. Use about half as much Pyro Powder as black powder. Do not use smokeless powder to drive shells.

The mortar length should be about five times its I.D. for shells 3" and larger. Smaller shell mortars need not be quite as long, and mortars used for firing multiple break shells should be somewhat longer. Shells are named by the I.D. of the mortar that fires them. Thus, shells fired from a mortar with 3" I.D. are called 3" shells. Sometimes shells are named for their circumference, rather than their diameter. A 3" shell would then be called a 9" shell. Even though a shell may be called a 3" shell, it is actually somewhat smaller in diameter (about 2-3/4"). This is so that it may fit easily in the mortar and also allow space for its 'leader' of fuse.

There are various types of bursting charges. Each shell has its own type and amount, depending upon its effect. Generally there are three types, refer to table L-105-1.

Table L-105-1 Burst charge compositions

Type I Meal Powder	1	Type II	FFFg black rifle powder
FFFg black rifle powder.	1		
Saltpeter	3	Type III	Meal powder
Sulfur	1-1/2		
Charcoal, dust	1		

The bursting charge is ignited by a time fuse. This is a short length of specially made safety fuse from 1/4" to 3/8" in diameter. time fuse is ignited either by the driving charge or by the leader. Its length varies with the type of shell. The burning time for all special fireworks time fuse is about 2.5 sec/inch. The time fuse should be thickly primed on both ends. This is of the utmost importance. The use of regular blasting fuse is not recommended. It does not burn with a trail of sparks so the trajectory of the shell cannot be determined and a misfire or a potential low burst cannot be spotted.

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BASIC AERIAL SHELLS

There are many types of shell casings that hold the garnishments and various effects, each type depends upon the particular effect the shell is to produce. There are two shapes of casings: Spherical and cylindrical. In the past, shell casings were often made in a spherical shape, but now in this country they are made almost exclusively in the form of cylinders. For the same diameter, cylindrical shells hold more display material than spherical ones; they are faster and easier to construct; and it is much easier to contrive them in a manner to procure multiple bursts. For specialized effects, spherical shells are used. The Japanese use spherical shells almost exclusively and achieve an almost perfect symmetrical break. The chief advantage in using a spherical shell is being able to achieve a symmetrical break much easier. This is especially so if ready made spherical casings are used. These are available from Westech.

IV. BASIC DESCRIPTIONS

A. Composition formulas

Table L-105-2 Composition formulas (all parts by weight)

(Red)		#1	#2	#3 (Green)		#4 (White)	
Potassium Chlorate	6	6		Barium Chlorate	9	Potassium Nitrate	10
Strontium Nitrate	6			Shellac	1	Sulfur	3
Strontium Carbonate		1		Dextrin	1/4	Arsenic Sulfide	3
Charcoal, dust	2	1				Dextrin	1/2
Shellac	1	1					
Dextrin	1/2	1/2					

#5 (Yellow)		#6 (Blue)		#7 (Purple)	
Potassium Chlorate	4	Potassium Chlorate.	9	Potassium Chlorate	6
Sodium Oxalate	1	Paris Green	3	Copper Oxide	1
Charcoal, dust	1/4	Lactose	1	Strontium Nitrate	1
Shellac	1	PVC	1/2	Shellac	1
Dextrin	1/4	Dextrin	1/2	PVC	1/4

Formulas 1-7 are for regular stars (cut, pumped, or box-any size).

#8 (Gold)		#9 (Silver)		(Twinklers)	#10	#11
Potassium Nitrate	8	Potassium Nitrate	10	Meal Powder	24	25
Sodium Oxalate	4	Aluminum, bright	1	Aluminum, bright	3	3
Sulfur	2	Arsenic Sulfide	3	Antimony, sulfide	3	3
Charcoal, dust	1/2	Sulfur	3	Sodium Oxalate	4	
Dextrin	1/2	Red Gum	1	Dextrin	1	1

Cut or pump 3/4" x 3/4"

#12 (Gold Flitter)		#13 (White Flitter)		#14 (Sinter)	
Potassium Nitrate	4	Potassium Nitrate	17	Potassium Perchlorate	16
Sulfur	1	Sulfur	3	Barium Nitrate	1
Charcoal, dust	1/2	Charcoal, dust	3	Aluminum, bright	6
Sodium Oxalate	1	Antimony, Chinese needle	11	Red Gum	1-1/2
Aluminum, bright	4	Aluminum, bright	10	Charcoal, dust	1
Aluminum Flitters	1/4	Aluminum, flitters	3	Dextrin	1-1/2
Dextrin	1	Dextrin	4	Cut 1/2 " x 1/2 "	

#15 (Spreader)		#16 (Splitter)		#17 (Red Electric)	
Potassium Nitrate	7	Potassium Nitrate	8	Potassium Perchlorate	24
Sulfur	1-1/2	Barium Nitrate	4	Strontium Nitrate	12
Charcoal, dust	2	Sulfur	2	Aluminum, bright	8
Charcoal, coarse	1-1/2	Charcoal, dust	2	Charcoal, dust	1
Dextrin	1/2	Antimony, Chinese needle	2	Shellac, orange	2
Zinc, dust	20	Aluminum, bright	1	Dextrin, yellow	2
		Dextrin	2		

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BASIC AERIAL SHELLS

Table L-105-2 Composition formulas continued

#18 (Green Electric)		#19 (Blue Electric)		#20 (Snowflake)	
Potassium Perchlorate	4	Potassium Perchlorate	14	Potassium Chlorate	2
Barium Chlorate	8	Aluminum, bright	6	Lampblack	3
Barium Nitrate	8	Barium Carbonate	1	Aluminum, bright	1/2
Aluminum, bright	6	Paris Green	10	Dextrin	1/2
Charcoal, dust	1-1/2	PVC	2		
Red Gum Yacca	2	Dextrin, yellow	1		
Dextrin, yellow	1	Shellac, orange	2		

#21 (Willow Stars)		#22 (Steel Stars)		Formulas #23 - #28 are for special Magnesium stars (cut, pumped, box-any size). They burn with a very brilliant light, much like stars containing aluminum. The Magnesium should be about 100 mesh.
Lampblack	12	Saltpeter	16	
Potassium Chlorate	8	Meal Powder	2	
Potassium Nitrate	1	Charcoal	2	
Dextrin	1	Steel filings	5	
Shellac	1/2			

Formulas 8-22 are for special stars (cut or pumped only-any size, except as noted).

(Magnesium Stars)	#23	#24	#25	#26	#27	#28
Material	(Bright)	(Amber)	(Red)	(Green)	(Blue)	(Crimson)
Magnesium	1	1	4	1	2	3
Shellac	1	1	1	1	1	1
Saltpeter	5					
Potassium Perchlorate		4	7		8	
Sodium Oxalate		2				
Strontium Nitrate			4			1
Barium Chlorate				3		
Paris Green					4	
Stearic Acid					1	
PVC					1/2	

Formulas #23 - #28 should be dampened with alcohol only to dissolve the shellac. The shellac gives the metal a protective coating to keep it from being oxidized.

Except for formulas #23 - #28 all star formulas should be mixed well with 24 mesh mixing sieves and then moistened with a 50:50 mixture of water alcohol. Only practice will tell how much to dampen, but the mixture should have the consistency of bread dough. If the stars are dampened too much, they will not perform properly; if they are dampened too little, they will crumble. Form into pumped, or cut stars, and while still damp, dust with meal powder and barium carbonate. Then allow to dry at least five days in a warm place. The meal powder should have added to it 1/10 part Barium Carbonate to act as a neutralizer to any acid that may be present in the sulfur of the meal powder. It is especially important to have this neutralizer present in the meal powder when using it to prime chlorate containing stars. If not, spontaneous combustion may result from some free acid reacting with the chlorate.

Formula #15 is a very effective star. They throw two kinds of sparks when they burn, masses of brightly burning zinc and particles of glowing charcoal. Because of the zinc which they contain, spreader stars are much heavier than other stars. Aerial shells cannot carry as many or a larger driving charge must be used.

Formula #16 also makes very surprising stars. They split into bright fragments while burning and burst as they finish, producing a fine palm-tree effect. #14 also produces a beautiful effect.

A small quantity of stars using formula #21 give an unusual fullness to any shell. The ingredients must be mixed thoroughly in order to obtain the desired effect. This is somewhat difficult because of the difference in weight between the bulky lampblack and compact potassium chlorate. Dampen the lampblack first with the water/alcohol mixture and then add the other ingredients.

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BASIC AERIAL SHELLS

B. Casings

Cylindrical casings are made by wet-rolling any type of paper around a suitable former. This may be a wooden dowel or metal pipe about 8" long and with an O.D. equal to the desired casing I.D. The formers available at Westech are ideal. The former should be coated with paraffin and then before each rolling given a good layer of paste so the casing will not stick to it and can be easily removed. Table L-105-3 gives the various dimensions for cylindrical shell casings (shown in inches).

Table L-105-3 Casing and mortar dimension table

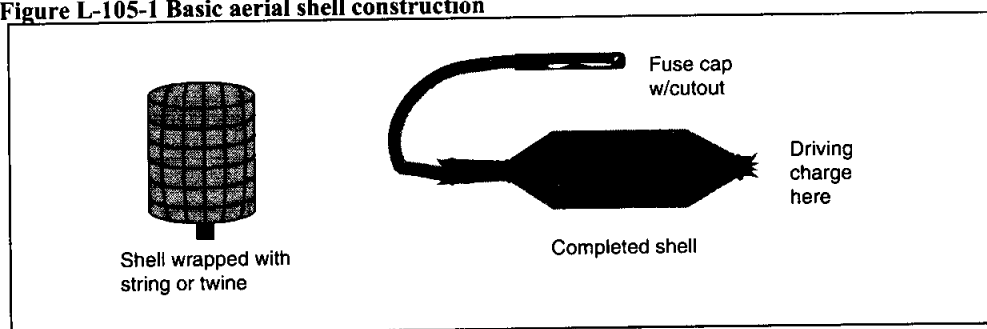
Mortar I.D.	Shell O.D.	Shell I.D.	Shell Wall Thickness	Shell Length
1-1/4	1-3/16	1	3/32	2-1/2
2	1-15/16	1-11/16	1/32**	*
3	2-3/4	2-9/16	1/32**	*
4	3-3/4	3-1/2	1/32 **	*

*The length of a display shell varies, depending upon the contents and the number of breaks. For example, a 3" single break star shell has a length of 3"; a 2-break 3" star shell has 2 casings, each 2-1/2" long; a 3-break 3" shell has three casings, each 2" long; a special effects 3" shell (such as whistles, fish, and stars) may be 5-1/2" long.

**In addition to the shell wall, the casing is wrapped with twine and then more paper. The twine gives the shell more strength and is responsible for the symmetrical break. The outside layer of paper gives the shell a smooth surface (for decreased wind resistance), additional strength, and a closer fit in the mortar. In addition, this paper secures the quick match leader and driving charge for exhibition shells.

End closures are made from 1/8" chipboard, and secured in the casings using Prof. Pyro Ad. In the past wooden discs were used for end plugs but chipboard plugs have less "fall-out", are lighter, easier to make, and less expensive. There is an endless variety of garnishments that the bursting charge distributes in the sky. The many types listed in our publications cover most of the best known varieties. But the ingenuity and imagination of the pyrotechnist will suggest others as he progresses and applies and expands the principles given.

Figure L-105-1 Basic aerial shell construction



V. PRODUCTS OF MANUFACTURE

2. Commercial Single-Break Shells

These shells are classified "Class C" fireworks, and are sold "over-the-counter" in some areas. They are 2" or less and come complete with a lifting charge and paper mortar.

1 Star Shells:

Compositions: Any type of star(s), Fg black rifle powder for the lifting charge, Type II bursting charge.

Casings: A shell casing made as explained in Part IV, a paper mortar secured to a wooden base with Professional Pyrotechnic Adhesive. Table L-105-4 shows the usual dimensions for commercial shells (sizes shown in inches).

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BASIC AERIAL SHELLS

Table L-105-4 Commercial mortar and shell size table

Mortar Size (Paper)				Shell Size		
Size	Length	I.D.	Wall	I.D.	O.D.	Length
#0	3	3/4	.040	5/8	11/16	2-1/8
#1	5	1	.048	3/4	15/16	2-1/2
#2	6	1-1/4	.048	1	1-3/16	2-1/2
#3	7	1-1/2	.055	1-1/4	1-7/16	2-1/2
#4	8	1-3/4	.125	1-1/2	1-11/16	2-1/2
#5	9	2	.125	1-11/16	1-3/4*	2-1/2

*Should be wrapped with string (parcel post, 6-8 ply) and finished with more paper to give a full burst. This will give a total O.D. of about 1-15/16".

If the paper mortar is to be rolled by hand, great care must be used to achieve a very strong tube. Use a good quality paper (Kraft or Manila), apply plenty of force when wet-rolling, and apply plenty of paste. Mailing tubes or other strong paper tubes give good results.

Ignition: 1/4" special fireworks time-fuse, priming, safety fuse.

Materials: Professional Pyrotechnic Adhesive., circular piece of thin chipboard.

Tools: Former for rolling the casing (if hand rolled).

Manipulation and Procedure: Bore a 1/4" hole in the center of a chipboard disk. Secure well with Professional Pyrotechnic Adhesive. Cut a length of time fuse about 1" long. The exact length will have to be ascertained by experimentation. Each shell varies, depending upon its weight, size, etc., and these factors determine how far up the driving charge sends it. The break should occur just as the shell starts its downward flight.)

About 1/4" of the fuse should extend on one side of the disc (the side that is to be outside); the rest should extend on the other side. Prime well both ends of the fuse and allow to dry. When both priming and Adhesive are dry, use adhesive to secure the fused end closure in a casing, making sure that it fits flush with the ends and the 1/4" section of time fuse is on the outside. When the Adhesive is dry, fill nearly to the top with stars, leaving a 1/8" space to secure the other end closure.

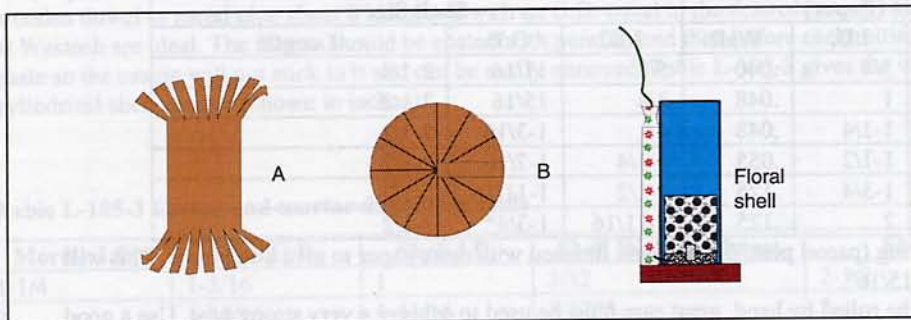
Place the filled shell on a balance to determine the amount of bursting charge. Pour in Type II bursting charge and secure the end closure with Adhesive. The exact amount of bursting charge varies with the size of the shell and its contents. Generally, about 1/4 oz. is used for every 1 oz. of stars. At this point the shell is considered complete for commercial over-the-counter sale. However, unless it is wound with string and further finished, it will not give a full break, but one very similar to a rocket, by merely blowing out the end.

First, wind it lengthwise. Wrap the string as tightly and as firmly against the fuse as possible. Each time that the string passes the time fuse, turn the shell so that about 15 -16 turns are wrapped evenly around the shell. Now wrap about 10-12 turns around the sides of the shell and at right angles to the first winding. Cut the twine and secure the loose end with adhesive.

Now cut some Kraft paper one diameter longer than the shell, or a little more, and soak it thoroughly with thin paste. Roll about two layers around the shell, leaving an equal amount projecting at each end. With scissors, snip the projections into 1/2" strips longitudinally (Fig. L-105-2 A) and work over top and bottom as neatly as possible so that they lie evenly and tightly around the fuse and there are no openings in the bottom (Fig. L-105-2 B).

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BASIC AERIAL SHELLS

Figure L-105-2 Shell wrapping example



Punch a small hole in the mortar about 1/4" above where it is secured to the base. Insert a length of safety fuse and pour in the required amount of lifting charge, drop in the completed shell (fuse end down); and push in the circular piece of thin chipboard, cut to fit snugly the inside of the mortar so it secures the shell and lifting charge.

2. Floral Shells

These are made exactly as above, refer to Fig. L-105-2. Take a Roman candle little longer than the mortar and punch a hole in its side near the bottom star. Fit in piece of quick match, bare the other end and slip it into the mortar through a hole punched in its side. Fasten the candle to the side of the mortar with wire and the floral shell is completed.

3. Single Break Exhibition Shells

These shells are 3" or longer and fired from commercial iron or steel pipe. They are classified as "Class A" fireworks.

Compositions: Any variety of star, Fg black rifle powder for a lifting charge, Type I bursting charge.

Casings: A shell casing made as explained in Part IV. For all around use, a 3" shell can produce breaks that equal most of the larger diameter shells.

Ignition: 3/8" Special fireworks time fuse, priming.

Materials: Professional Pyrotechnic Adhesive.

Tools: A former for rolling the casing (if hand-rolled).

Manipulation and Procedure: The shells are made exactly as explained above under "star shells." However, use strong twine instead of string, 3/8" fuse instead of the 1/4" variety, Type I bursting charge instead of Type II.

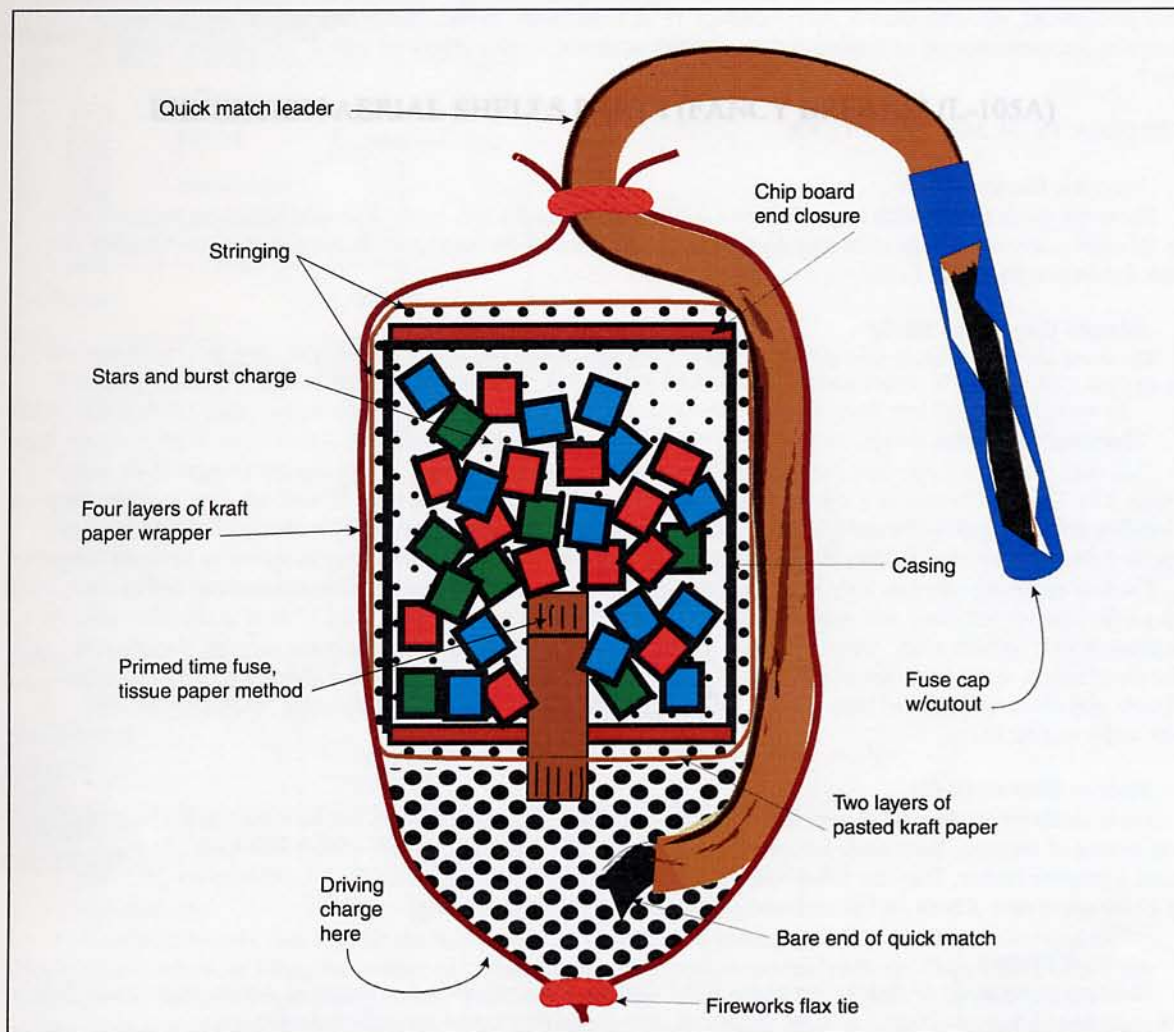
When the shell is completely dry, take a 2' piece of quick match and lay it along the side of the shell. The quick match should extend about 3" beyond the end with the time fuse. Both the quick match and shell are dry rolled up as tightly as possible in four thickness of Kraft paper, wide enough to extend one diameter beyond each end of the shell.

The shell is now turned bottom end up. About 2" of the paper pipe of the quick match is removed to expose the black match. Make sure that the time fuse is well primed and has no paste, Adhesive, etc., on the priming. The driving charge is introduced and the paper wrapping is tied securely and trimmed close to the string. The other end of the wrapping is tied securely around the quick match and a few inches of black match bared at the end. This piece of black match, for safety's sake, is now covered with a close fitting paper tube, closed at one end, which is to be removed after the shell has been placed in the mortar and is ready for firing. Refer to figure L-105-3.

There are many beautiful effects using a single break of stars. Some especially good ones are: Blue and gold flitter; blue and white flitter; gold and white flitter; twinklers; spreaders, splitters; weeping willow; gold and silver, red and silver; red and green; red and blue; blue and silver; purple, red and gold; red, green and saver; red and yellow; red and gold; blue and yellow; purple and green; gold, red and green; "electric" stars; magnesium stars.

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BASIC AERIAL SHELLS

Figure L-105-3 Completed aerial shell, cutaway view



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EXHIBITION AERIAL SHELLS PART I (FANCY BREAKS) (L-105A)

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(L-105A)
PART I (FANCY BREAKS)
EXHIBITION AERIAL SHELLS

I. INTRODUCTION

The aerial shells that make up the "Exhibition" series are all 3" or larger. All of the theory, general principles, safety precautions, etc. discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells. Unless otherwise stated, the bursting charge is Type I.

II. PRODUCTS OF MANUFACTURE

A. Meteoric Shower Shells

These are shells loaded with large (3/4" or 1-1/4") stars, generally red, green, and gold (formulas #17, #18, and #8). Of course, any other large stars may do also. Make the same as for regular shells described under "Single Break Exhibition Shells" in L-105.

B. Spangle (Streamer) Shells

These are shells that break into large (3/4" or 1-1/4") tailed stars (formulas, #8, #9, #12, #13, #14, #15, #16, #20 #21).

C. Thunderbolt Shells

This shell produces a very surprising effect, especially if fired immediately after a regular spangle shell using formula #20. The shell breaks as a regular spangle shell, but after all of the rest have burned out, four spangles keep on burning and falling. All of a sudden they explode just before they hit the ground. This always elicits laughter and surprise from the spectators, as they think some mistake was made when the four spangles appear to burn too long.

The four reporting spangles may be made from 1/2" I.D. x 1-1/2" long casings. Insert an end cap and secure with professional pyrotechnic adhesive. Fill about 1/3 full with flash powder. Punch a 1/8" hole in the other end cap and prime it well on both sides. When dry, push it into the casing until it almost reaches the powder. Secure with Adhesive. Push in some damp comp. #20 until it fills the remainder of the casing and overflows on top. Prime this end well, and allow to dry for at least a week. Fill a shell with regular spangles plus the four "thunderbolts" and finish as for regular shells.

D. Rain or Shower Shells

These shells are made and "strung" like single layer serpent shells (see below), but they are filled with rain cases instead of serpents. Rain cases are about 2" long x 1/2" I.D. and made by wet-rolling four turns of paper around a suitable former. They are filled with #8 (but substituting Red Gum Yacca for the Dextrin) for gold rain, and #9 for silver rain. About 1/8" in each end of the case is filled with priming.

E. Peacock Plumes

These are cases made as above. One end is filled with a star composition the other with a rain composition. The shell is made as for single layered serpent shells (see below) and produces a very effective display.

F. Palm Boughs

These are made like Peacock Plumes except 6 to 10 small (1/4") stars are substituted for the rain. These are especially effective if small green stars are used which produce the effect of a blooming flower, complete with green stem and colored blossoms at the end.

G. Granatine

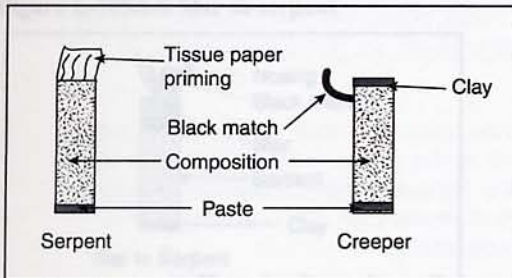
Take a 1/2" I.D. x 1-1/2" long casing; plug one end with an end cap and secure with professional pyrotechnic adhesive. When dry, pour in some flash powder. Punch a 1/8" hole in another end cap, stick a 1/2" piece of black match through and prime well on both sides. When dry, insert and secure with adhesive. When dry, wet-roll four turns of paper around the case so there is about a 1-1/2" projection on the end that has the match. Fill with small (1/4") stars and then match and nose. Fill and string the shell like single or double layered serpent shells.

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PART I (FANCY BREAKS)
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H. Serpents:

Serpents come in two varieties, regular and creepers. Figure L105A-1 shows the construction of each type.

Figure L-105A-1 Serpents



1. Regular

These are cases 1/4" I.D. X 2-1/2" long made by wet-rolling four turns of strong paper. When dry they are driven full with the composition given below in table L-105A-1. One end is primed well and has a short piece of black match stuck in the priming; the other is thoroughly covered over with paste or dipped in Sodium Silicate.

2. Creepers

One end of the case is filled with about 1/4" driven clay. It is then filled with composition and the other end is covered with paste, etc., as above. A hole is then punched in the side, just above the clay. The hole is primed well and a piece of black match inserted.

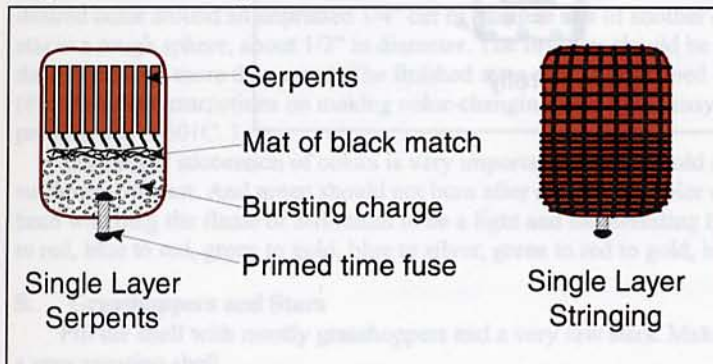
Table L-105A-1 Serpent and Saucisson composition

Material	Serpents	Saucissons
Meal Powder	7	4
Saltpeter	2	2
Sulfur	1	1
Charcoal, dust	1	1
Iron filings, 40 mesh	3	3

I. Serpent shells

Are made differently than regular shells. Instead of a symmetrical break, the shell should blow one end out. This is accomplished by filling the bottom of its shell casing with serpents, primed ends up. Then a thick mat, made from pieces of black match, is placed on top. The bursting charge is poured on top of the mat as shown in the drawing. The part of the shell containing the bursting charge is wrapped with triple the amount of twine. Refer to figure L-105A-2

Figure L-105A-2 Serpent shell construction

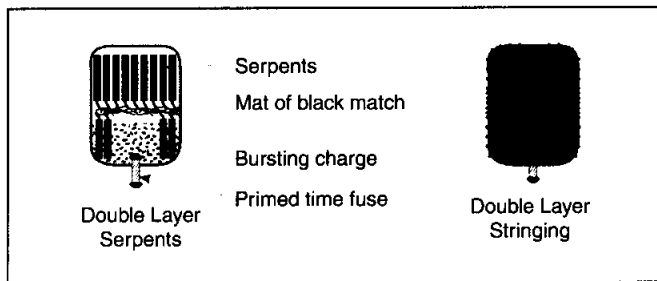


J. Double Layer Serpent Shells

The shell casings are made a bit longer and then filled as is above. But the bursting charge only occupies the center of the upper half of the casing, around the walls are placed serpents, about one or two layers thick with primed ends down, see drawing. Only a band around the center of the casing is wrapped with extra twine. (see figure L-10A5-3) so both ends can blow out.

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Figure L-105A-3 Double layer serpent shell construction



K. Serpents and Stars

Stars may be placed with the bursting charge for single layered serpent shells to give a pleasing effect.

L. Saucissions

These are made like bounced fountains using a case $\frac{3}{8}$ " I.D. x 3-1/2" long x $\frac{3}{32}$ " wall. Fill and construct the shell as for single layered serpents. Saucissions without the bounce are sometimes called "fish." Very effective shells can be made by combining saucissions and /or fish with whistles and/or stars.

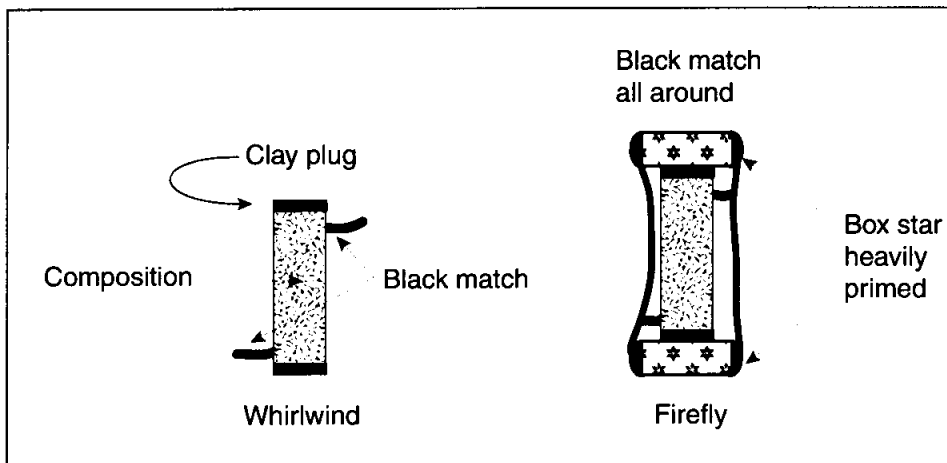
M. Whirlwinds

These can be made any size but generally are $\frac{5}{8}$ - $\frac{3}{4}$ " I.D. x 3" long. They are constructed as shown in figure L-105A-4. Use saucission composition in the whirlwinds.

N. Fireflies

These have a box star glued to each end of a whirlwind. A shell filled with these is a very effective item. Fill and "string" the case as for single layered serpent shells for both whirlwinds and firefly shells.

Figure L-105A-4 Whirlwind and firefly construction

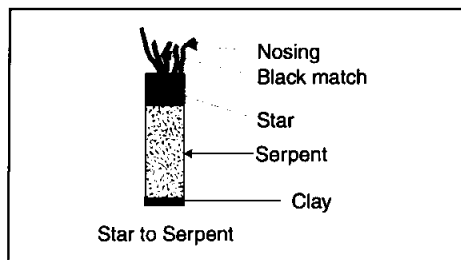


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O. Stars to Serpents

These are constructed as shown in figure L-105A-5. These make a very effective surprise shell. Fill and string as for either single or double layered serpent shells.

Figure L-105A-5 Star to serpent



P. Stars to Whistles

Same as above but use whistle composition. instead of the serpent formula. These shells are sometimes called "Musical Shells."

Q. Stars to Thunder

A very effective shell, especially if the report compositions are colored, the stars disappearing in a rainbow of colored flashes and reports. For the above three, the damp star composition should be rammed in the case first. When it is dry (allow at least three days), the other compositions are added dry the serpent and whistle compositions being rammed into the case. The thunder composition is merely poured into the case. (If a damp star composition containing a chlorate came into contact with another composition containing sulfur or one of its compounds, upon drying, the article could ignite from only a slight jolt.

Table L-105-2 Rainbow report compositions

Rainbow Reports	Red	Green	Yellow	Blue	Violet
Magnesium 100 mesh	1	1	1	1	2
Strontium Nitrate	1				1
Barium Nitrate		1			
Sodium Oxalate			1/2		
Paris Green				1	1
PVC		1/8		1/8	1/8
Potassium Perchlorate			1	1	

R. Color Changing Stars

A shell filled with these is extremely effective. All that is necessary to do is to press a dampened mixture of the desired color around an unprimed 1/4" cut or pumped star of another color. This is done with the fingers until the star is a rough sphere, about 1/2" in diameter. The first star should be dry; the second mixture may need to be dampened a bit more than usual. The finished stars should be primed as usual. Fill and string as for a regular shell. (For complete instructions on making color-changing stars by an easy, quick, and inexpensive mass production process, see L-601C.)

The proper succession of colors is very important. Green should not be next to white, for there would not be sufficient contrast. And green should not burn after red, for the color of the barium flame appears to one who has been watching the flame of Strontium to be a light and uninteresting blue. Some suggested color changes are: green to red, blue to red, green to gold, blue to silver, green to red to gold, blue to silver to red, gold to green to red.

S. Grasshoppers and Stars

Fill the shell with mostly grasshoppers and a very few stars. Make and string as for a regular shell. This makes a very amusing shell.

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T. Devil-among-the-tailors

This shell is filled with grasshoppers and one whistling saucisson. The saucisson is made as usual but with a whistle case attached to its side. Make and string as for a regular shell. The whistle should be 2-1/2" long x 5-16" I.D. x 9/16" (about) O.D. Plug one end with about 1/8" clay and then ram to within 1" of the top with whistle comp. The 1" vacancy is necessary for the production of the whistle sound. Prime, match, and nose. Glue and tie to the primed, matched, and nosed saucisson.

U. Conch Shells

This consists of placing specially made 3-ball Roman candles in the bottom of a shell, like single-layered serpents. The candle casings are made of very strong paper so they can be thin and no empty portion is left on top or bottom. In addition, not as much candle comp. is used so the candles fire more rapidly. Some stars are added to the bursting charge and the shell is filled and strung like a single layered serpent shell. The candles should be well-primed and have several strands of black match protruding from the nosing.

V. Military Shells

These are shells filled with M-80-type salutes. The fuses should be about 1/4" long and secured firmly in their holes with Professional pyrotechnic adhesive. They should be heavily primed on the outside and a short piece of black match stuck in the priming to insure ignition. The effect is quite startling as upon bursting all the air, this shell remains dark for a few moments to enable the salutes to form a full circle, then all ignite at the same time.

W. Thunder Shells

These shells are filled with flash crackers and then strung like regular shells.

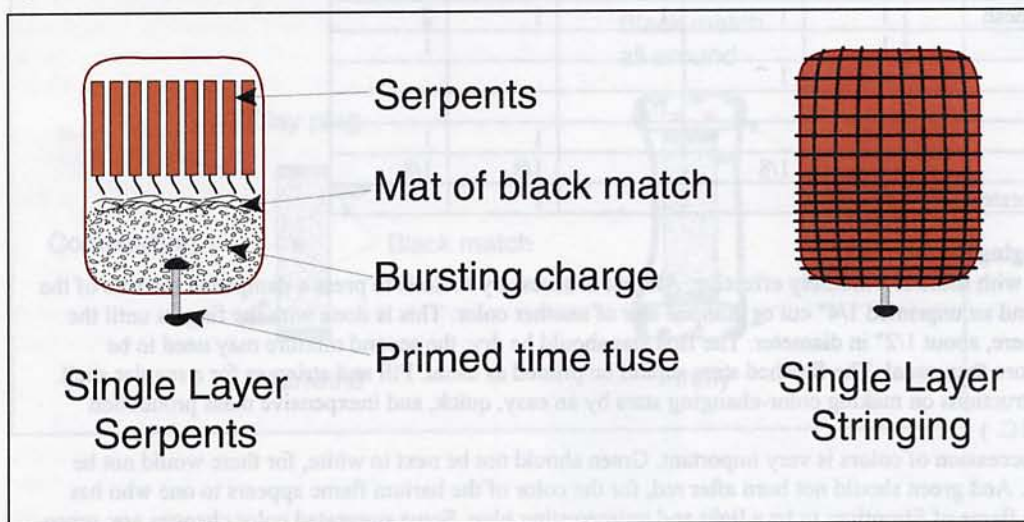
X. Thunder and Rainbow Shells

These are made like regular shells but use half stars and half flash crackers. effective are colored magnesium flash formulas.

Y. Thunder and Whistles, Rainbow and Whistles

Are also effective shells. Whistles should be well primed, nosed and matched.

Figure L-105A-6 Serpent shell construction enlarged view



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EXHIBITION AERIAL SHELLS PART II (PATTERNED BREAKS) (L-105B)

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(L-105B)
PART II (PATTERNED BREAKS)
EXHIBITION AERIAL SHELLS

I. INTRODUCTION

The aerial shells that make up the "Exhibition" series are all 3" or larger. All of the theory, general principles, safety precautions, etc., discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells. Patterned break shells take much time, patience, skill, and experimentation to achieve successful and symmetrical patterns.

II. PRODUCTS OF MANUFACTURE

A. Spider Web Shell

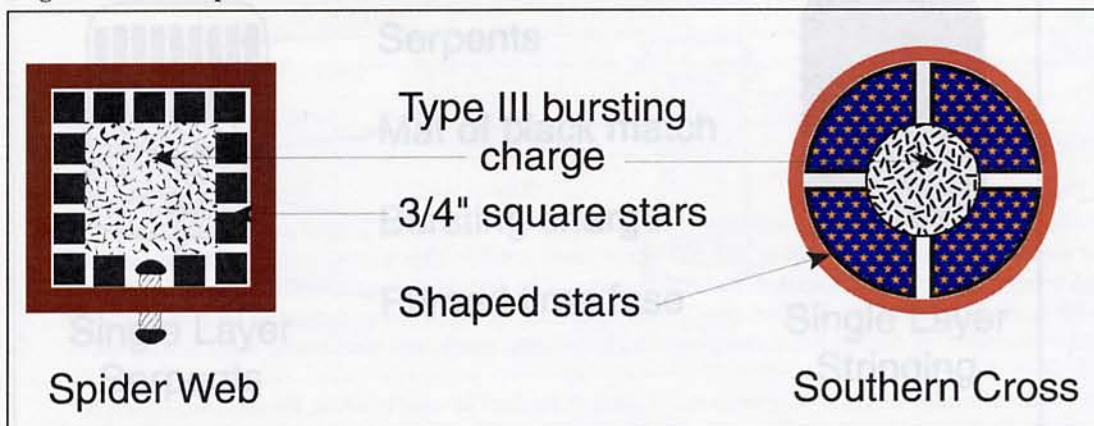
This shell produces several long, evenly spaced tentacles that reach for tremendous heights and almost to the ground. This produces a very surprising change from other regular break shells. The stars are pumped approx. 3/4" x 3/4" from the following composition described in table L-105B-1. Mix well and dampen with a 50/50 mixture of water/alcohol

Table L-105B-1 Spider Web composition

Materials	Parts
Meal Powder	33
Charcoal, dust	6
Saltpeter	4
Lampblack	1
Sulfur, flour	8
Dextrin	1

The casing is rolled as normal, height should be equal to O.D., but it is filled and strung in a special way. Place a single layer of stars in the casing so it covers the bottom as completely as possible. Then stack stars on top of each other around the walls so they form a single layer thick from top to bottom (see diagram). Fill the center vacancy full with Type III bursting charge, leaving just enough space at the top to place a layer of stars. In wrapping the shell with twine, it should be completely covered so the casing cannot be seen, Wrap the twine very tightly and finish as for a regular shell. **Type III burst**

Figure L-105B-1 Spider Web and Southern Cross construction



(L-105B)
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EXHIBITION AERIAL SHELLS

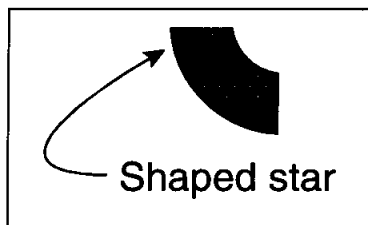
B. Southern Cross shell

This shell produces a dark center (where the shell breaks) and then four equally spaced arms, making a spectacular cross of fire in the sky. The stars are made from the following composition described in table L-105B-2.

Table L-105B-2 Southern Cross composition

Materials	Parts
Meal Powder	12
Saltpeter	36
Antimony, Chinese Needle	12
Sulfur, flour	10
Dextrin	2

Figure L-105B-2 Southern Cross shaped star construction



Mix well, dampen with a 50/50 water/alcohol mixture, form into the special shape as shown in figure L-105B-2. The stars are molded into a special shape. They cannot be cylindrical or any other shape because the bursting charge (Type III) will not have sufficient force to throw such huge stars into the proper pattern.

The casing is rolled and strung as in figure L-105B-3 except the height equals O.D.; and twine covers the entire casing. The four stars are placed around the outside and the bursting charge in the center, see figure L-105B-1. Magnesium or electric stars, shaped as in figure L-105B-2, also make a very striking display, especially if different colors are used. **Type III burst**

C. Octopus Shell

This is the same as the above except the stars are exactly half as large but twice as many, and use the formula for Splitter stars instead of the above. **Type III burst**

D. Weeping Willow

This shell produces one of the most beautiful effects available in pyrotechnics. The stars are made from the following composition described in table L-105B-3.

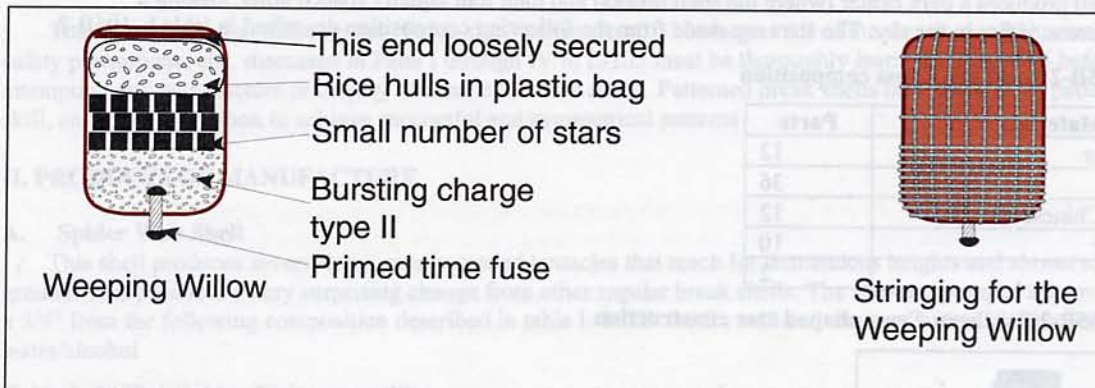
Table L-105B-3 Weeping Willow composition

Materials	Parts
Meal Powder	8
Lampblack	6
Antimony Sulfide	1
Shellac	1/4

Mix well. The effect of this star is entirely dependent on how well the ingredients are incorporated. Dampen with alcohol only, press and cut into 3/4" cubes. The stars and bursting charge are all placed in the bottom half of the casing, the top half being filled with rice hulls or other nonflammable material. (see figure L-105B-3 left illustration). To achieve the hemispherical, drooping effect, a very light bursting charge is used (only about 5 grams for a 3" shell) and the shell is especially strung. The half that contains the bursting charge is given a triple amount so only one end is blown out (see figure L-105B-3 right illustration). The shell is then finished as normal. **Type I burst**

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Figure L-105B-3 Weeping Willow shell construction



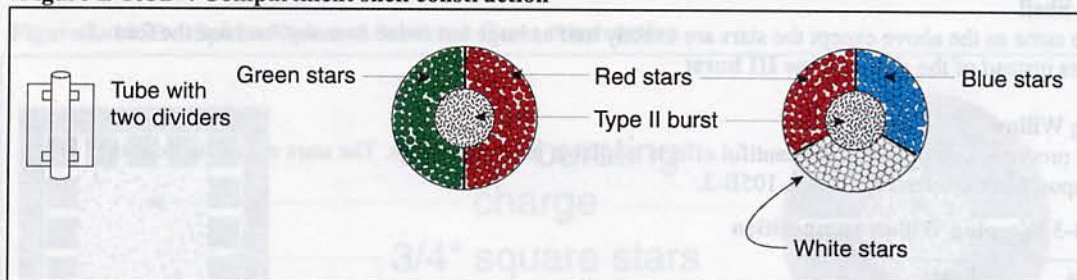
E. Double Ring Shells

These produce a circle of stars with the center stars being one color and the outer ring of stars of another color. The shell casing is made as normal but it is filled in a special way. A piece of stout paper is rolled into a tube a few inches longer than the shell and with a diameter equal to $1/2$ the I.D. of the shell, see Figure. Place this in the exact center of the casing and then fill the space between it and the shell wall with stars; one color is placed against the tube, and the other between these stars and the shell wall. Pour bursting charge into the tube until full. Make sure the stars and bursting charge are well seated. Now withdraw the tube, leaving a center core of bursting charge with stars around the outside. String and finish as for a regular shell. A very effective shell is using color changing stars for both the center and outer ring. **Type II burst**

F. Compartment Shells

These produce a circle of stars. The colors are not mixed but distributed by color, each sector of the circle has a distinct color. Make a tube of paper as shown, and attach 2 or 3 paper dividers to it, see figure L-105B-4 below. The center is filled with bursting powder and each compartment with different colored stars. **Type II burst**

Figure L-105B-4 Compartment shell construction



EXHIBITION AERIAL SHELLS PART III (MULTIPLE BREAKS) (L-105C)

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(L-105C)
PART III (MULTIPLE BREAKS)
EXHIBITION AERIAL SHELLS

I. INTRODUCTION

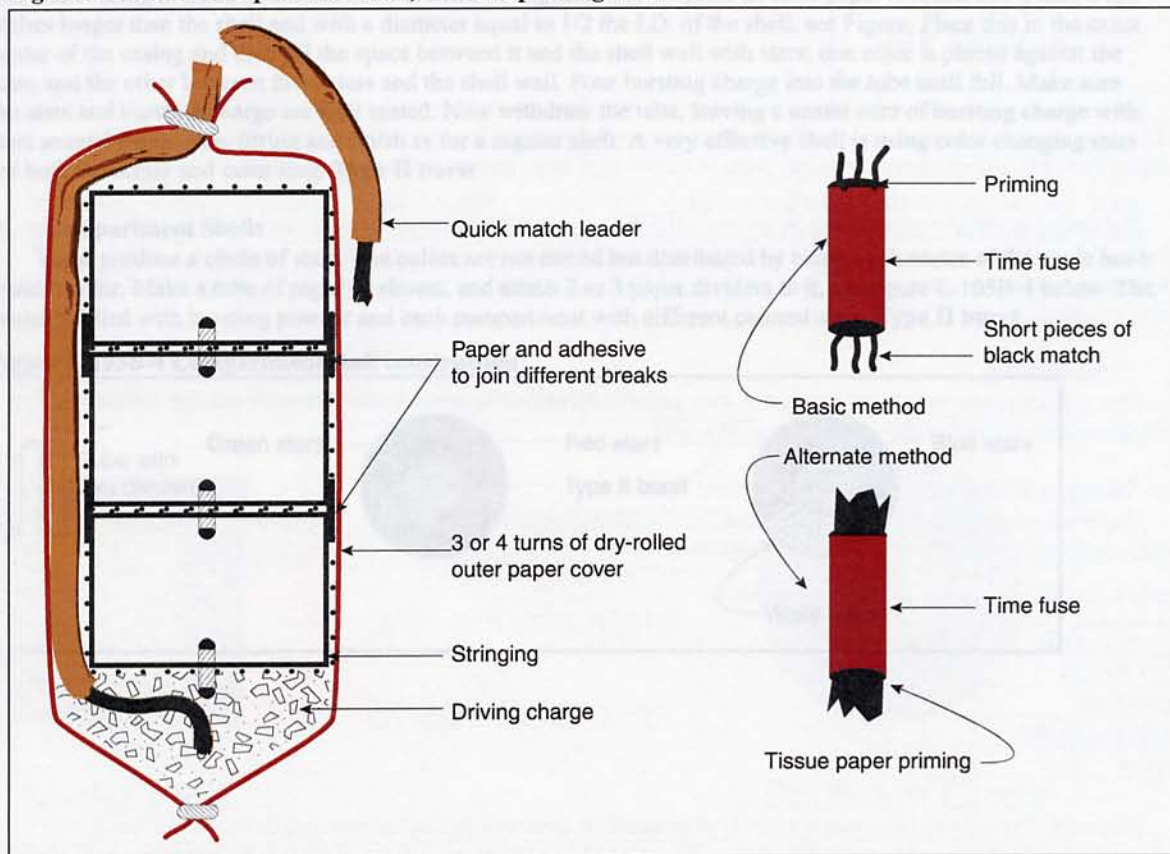
The aerial shells that make up the "Exhibition" series are all 3" or larger. All of the theory, general principles, safety precautions, etc., discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells. Unless otherwise stated, the bursting charge is Type I.

II. PRODUCTS OF MANUFACTURE

A. Regular Multiple Break Shells

The usual number of breaks is two, three, or four. Any type of shell may be used for any break. If salutes are used, they are usually used for the last break. The length of each casing of a 3" two-break shell is 2-1/2"; a three-break shell has three shell casings, each 2" long; a four-break has four casings, each 1-1/2" long. In general, the total length of all the smaller shells put together should not exceed 6" (for 3" shells). Each shell is made, filled, strung, etc., as when making any type of single break shell, except the casings are shorter, and each end closure has a 3/8" diameter hole in its center (if a 3/8" diameter time fuse is used.) One end closure has the time fuse secured as normal; the other end closure has the time fuse of the next shell protruding through the hole, see figure L-105C-1, left hand illustration.

Figure L-105C-1 Multiple break shell, and fuse priming methods



(L-105C)
PART III (MULTIPLE BREAKS)
EXHIBITION AERIAL SHELLS

Each shell is joined to the next by three or four turns of Kraft paper, about 3" wide 1-1/2" on each shell, see figure L-105C-1, left hand illustration. Make sure to use plenty of force when rolling the two shells together in this band of paper. Smear an entire side with thin Professional pyrotechnic adhesive instead of paste, and then roll up tightly.

All time fuses should be heavily primed, and have short pieces of black match stuck in the priming, see figure L-105C-1, right hand illustration. Only experimentation will tell how long to cut the time fuses. The first time fuse should be about 1" long for a two-break shell, somewhat shorter for a three-break and a bit shorter still for a four-break. Thus, some of the breaks will ignite just before the shell reaches the top of its trajectory, and some on their way back down.

B. Military Shells

This is a two-break shell; the first is a break of thunder, the second a heavy salute. A variation of this is to make a three-break shell; the first of thunder the second of M-80-type salutes, and the last a heavy report.

C. Report Releasing Spangles of Stars

The effect of this shell is quite surprising after watching several regular single break shells. The shell breaks with a huge report, but the stars do not scatter any faster than for a regular shell.

This is really a two-break shell, both breaks igniting simultaneously. Construct as for a regular two-break shell except the second break, which always must be the salute, does not have a time fuse; the time fuse hole is plugged with priming and pieces of black match that barely stick into the primed hole of the first break.

D. Hammer shells

This is a timed report and star break shell. Generally there are three star breaks and three salutes. First comes the star break, and then one second later, a heavy report. This sequence is repeated two more times. Each report and each star break follow each other by exactly one second. This shell is really three 2-break shells, each shell consisting of a star break and a salute. The three shells are loosely connected by an outside wrapping of a couple of turns of paper. The time fuses for the second and third star breaks are ignited by quick match connections that are securely tied to each time fuse and are ignited by the flame from the lifting charge. Time fuse and quick match connections should be so heavily primed that they stick together.

Great care and experimentation must be exercised in order to cut all time fuses the correct length, as the effect is entirely dependent upon the evenly spaced timing. An extra amount of driving charge should be used so all three shells are propelled to the necessary height.

This same method of igniting the second and third 2-break shells by quick match is an alternative way of achieving multiple break shells.

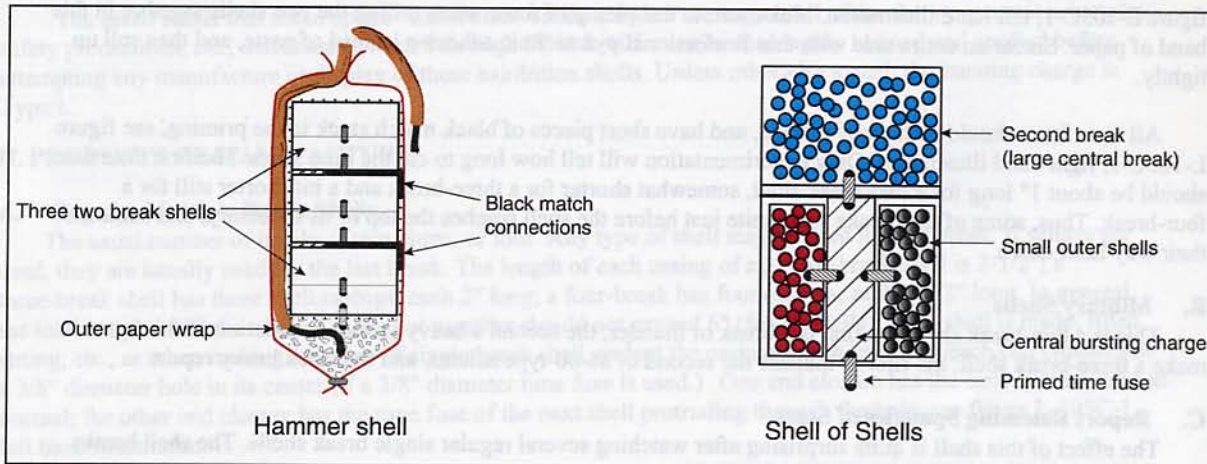
E. Shell of Shells

Upon bursting in the air this shell remains dark for a few seconds, to enable the smaller shells to form a circle around the center break, then all ignite at once, the smaller shells breaking in one color around a huge break in the center of another color. This is really a two-break shell. The second break is made, filled, strung, etc., as normal, and makes the large central break. The first break is specially made and contains the smaller outside breaks. Roll three or four turns of paper into a tube the same length as the shell casing of the first break and a diameter equal to about 1/3 its I.D. Place this tube in the exact center of the shell casing. Between this tube and the shell casing are placed several (at least six) small shells all around the outside. Each has a heavily primed time fuse of 1/8" fireworks fuse in its side that sticks into the central paper tube through a hole poked in its side when each of these small shells is placed around it. When the smaller shells are all in place, fill the tube with Type III bursting powder. Secure the top end closure and finish as for a regular two-break shell. All time fuses must be exactly cut so all shells break at the same time. The smaller shells are made, filled, strung, etc., as for regular single break shells, except for the time fuses, as noted above. A suggested color combination is for the smaller shells to break in red and silver; the central break in blue.

This shell takes considerable skill to make but produces a magnificent effect and is well worth the time it takes to construct. The larger they are, the easier they are to make and the better the effect. Generally, a 4" shell is the smallest size.

(L-105C)
PART III (MULTIPLE BREAKS)
EXHIBITION AERIAL SHELLS

Figure L-105C-2 Hammer and Shell of Shells



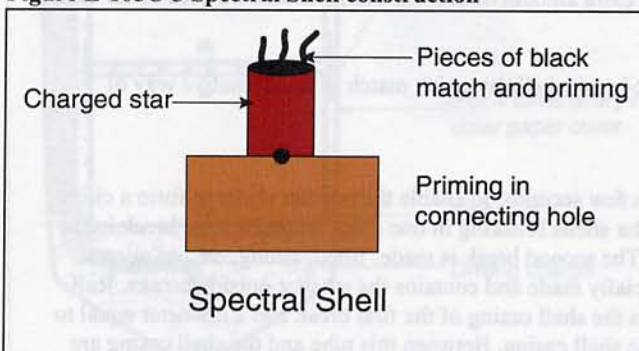
F. Three-in-One-Shell

This shell has almost the opposite effect as the above. Upon reaching its height, it bursts forth with a large spread of comets. While these outside stars are spreading, three smaller shells break in the center. This is constructed similar to a two-break shell. The first break consists of the comets placed around a central Type III bursting charge. The shell is then strung as for a normal single break shell. The second break casing is filled with three smaller shells with central 1/8" time fuses as for the Shell of Shells. These fuses should be well primed and cut very short, since the shells should break almost immediately after the bursting charge ignites them. The main time fuse to the second break should also be quite short.

G. Spectral Shell

This shell breaks into colored stars. As they fall, they, in turn, break into showers of different colored stars. Though very surprising, this shell is very simply constructed. It consists of a shell filled with items similar to bursting comets. The initial stars should be "charged" stars (box stars open on one end only), about 1/2" dia. x 1/2" long or larger. These are attached to larger casings filled with 1/4" or 3/8" stars and Type I bursting charge.

Figure L-105C-3 Spectral Shell construction

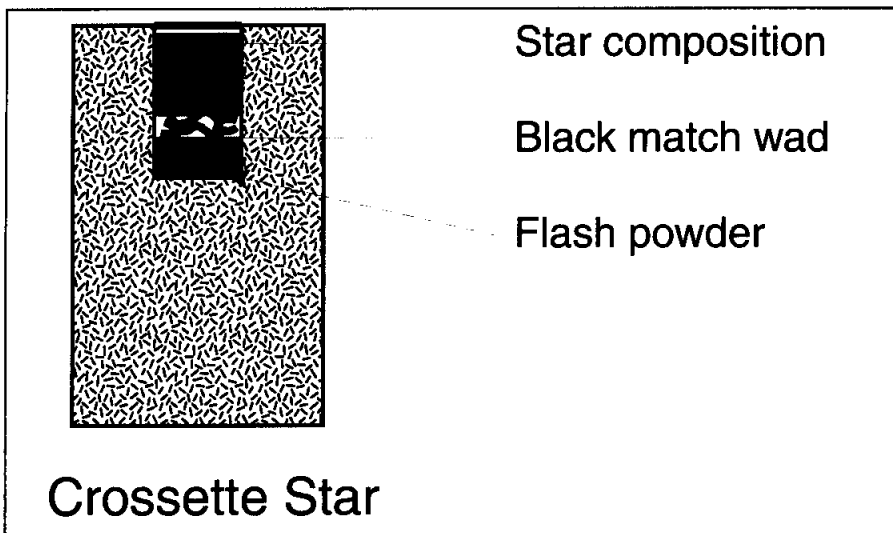


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PART III (MULTIPLE BREAKS)
EXHIBITION AERIAL SHELLS

H. Crossette Shell

This shell has an effect similar to the spectral shell, except the initial stars break with a sharp pop into smaller stars of the same color. The effect is achieved by filling the shell with 1-1/8" diameter pumped stars that have a cavity part way through their centers. A specially made star pump is used to make them. When dry, about 1/4 teaspoon of flash powder is poured into the cavity. A piece of black match is now rolled into a small ball and pressed into the hole so it forms a plug slightly above the powder. The remainder of the cavity is filled with damp star composition.

Figure L-105C-4 Crossette star



I. Surprise Halley's Comet Shell

This shell has a delayed comet. It ignites a short time after the shell is fired and burns out just before the shell breaks. The comet appears to be the only effect, and when the shell breaks, its effect is magnified by the surprise of the spectators who thought everything was over.

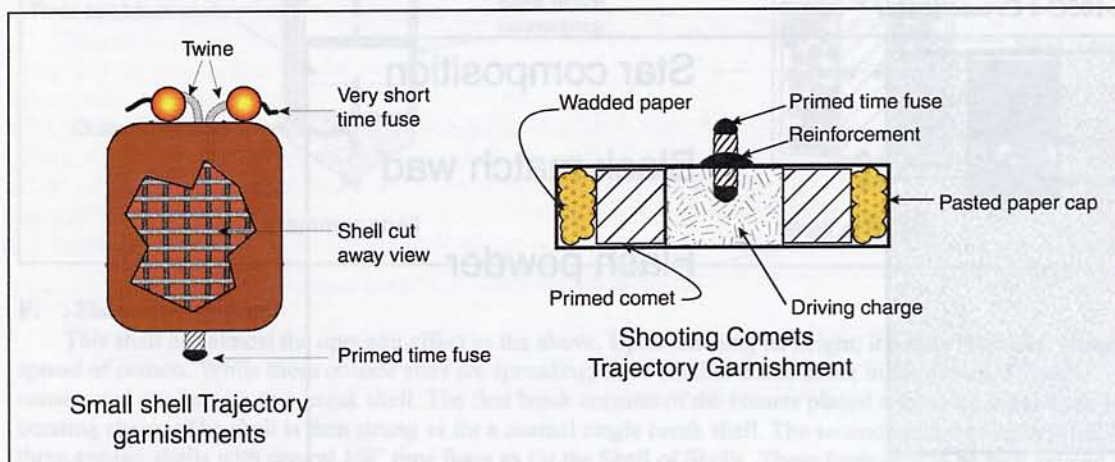
This shell is constructed as a normal single break shell except a very short (1/2", or less) time fuse is used and placed in the top end closure of the shell. A short tube (about 1/2" or less) whose diameter is just a bit smaller than the shell's is firmly secured to the top of the shell with Professional pyrotechnic adhesive. The inside is then packed solid with a silver comet composition; the top is well primed and nosed. Firmly tied into this nosing is a short piece of primed safety fuse. The driving charge ignites the piece of safety fuse which should be just long enough so as to delay the ignition of the comet until the shell is almost to its apex. The comet then burns with a spectacular silver trail for the remainder of the shell's upward flight and until it just turns downward. When it burns out, all is dark, for the time fuse's golden sparks are not noticed after the brilliant silver comet. Then the fuse burns through and the shell breaks with a surprise.

(L-105C)
PART III (MULTIPLE BREAKS)
EXHIBITION AERIAL SHELLS

J. Trajectory Garnishments

These are small fireworks items which are connected to the shell. They ignite on its upward trajectory. Some good suggestions are: small shells jetting out of trajectory (two or three cherry bomb casings filled with small stars work fine); two or three small comets jetting out of trajectory; silver or golden comet tails that trace the shell's upward trajectory; whistles, reports, crackles (grasshoppers). All of these effects should be fastened to the top of the shell with twine. They are ignited by the flame from the lifting charge.

Figure L-105C-5 Shooting comet and star trajectory garnishments



ROCKETS (L-106A)

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(L-106A)
ROCKETS

I. INTRODUCTION

Rockets in all their various forms are very popular. To make really good rockets requires skill and a constant observance of small details. Rockets can be very dangerous if constructed or fired without due precaution. Thus, all safety precautions given in this treatise must be followed to the letter.

Certain principles of pyrotechnical theory are given so the pyrotechnist can better understand the processes that are involved in making rockets. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since all fireworks items consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition nor the casing but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility for use.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. THEORY AND GENERAL PRINCIPLES

Rockets function on the principle that a burning composition confined within a cylindrical case produces gases which exert pressure on the walls of the case. If the case were closed, then the pressure would be exerted equally on both ends and the case would remain stationary. However, there is a hole in one end. This allows the gases to escape with a corresponding decrease in pressure at this end. Since the pressure at the opposite closed end is now greater as the result of the loss of gases at the open end, it pushes the case in the direction away from the closed end.

One of the most common mistakes in making rockets is to use Saltpeter that has not been sufficiently pulverized. Unless it is just like powdered sugar or flour, rockets will not perform properly.

Another mistake is not loading rockets in small enough portions. Unless the composition rises in the casing about 1/2" only with each scoop full (after being driven), the composition will not be consolidated enough for maximum performance. Do not be impatient when making rockets. Good ones take time to make.

III. COMPOSITION FORMULAS

A. Skyrockets

Various sizes of skyrockets use different formulas. Compositions that work for small rockets are too violent for large ones. This is because the burning area in a large tube is much greater and a tremendous amount of composition is ignited at once than in a smaller tube. No geometric proportionality applies to the surface area of composition ignited and the size of the tube. Thus, large rockets need slower burning compositions (accomplished by increasing the proportion of charcoal) than smaller rockets. The following compositions listed in table L-106A-1 are good, (All parts by weight).

Table L-106A-1 Rocket compositions

Material	2 oz.	4 and 8 oz.	1 and 2 lb.	4 lb.
Saltpeter	18	18	18	18
Sulfur, flour	4	4	4	4
Charcoal, dust	4	3	2	1
Charcoal (100 mesh)	3	3	2	2
Charcoal (40 mesh)	2	2	2	2
Charcoal (12-20 mesh)	-	2	2	3

(L-106A)
ROCKETS

The saltpeter should be like powdered sugar. If rockets burst before or while ascending, add more charcoal dust; if they ascent too slowly, add more saltpeter.

IV. PRODUCTS OF MANUFACTURE

A Skyrockets

A skyrocket functions as previously explained but in order to provide enough force to propel itself high into the air, the skyrocket is charged so that there is a conical hollow inside the powder core. This way, not only the end of the composition burns but the powder along the walls of the hollow. A very large amount of area of the powder is thus allowed to burn at once and produce the needed force. The hollow should extend about 6/7 of the way through the powder core. The last 1/7 is charged solid.

Compositions: Any of the formulas listed under skyrockets. Be sure to use the appropriate formula with the correct skyrocket size. Iron or steel filings may also be added to enhance the tail for display rockets.

Casings: These consist of two parts, the "engine" which contains the powder core, and the head which contains the garniture of stars, salutes, etc., that ignite when the rocket reaches its apex.

Engine: These should be wet-rolled, parallel wound from Kraft, Manila or chipboard to the following dimensions: taking the I.D. as 1, then the O.D. should be 1-1/2 times the I.D.; the length should be 10 times the I.D.

Head: There are two types of skyrocket heads. One consists of merely one or two turns of dry-rolled paper in the shape of a cone. Its height should be 4 times the rocket's I.D. It is best made by cutting some paper into a semicircle with a radius equal to the cone's desired height. The semi-circle is then rolled up into the cone. This type is very simple and used by commercial manufacturers.

The other type is more elaborate and can contain much more garniture. This type should be used when the best effects are desired. It consists of two parts: a head and a tip. The head is two turns of dry-rolled paper in the shape of a truncated cone (a cone with its tip cut off). This part has the same diameter as the O.D. of the skyrocket body, for it is this part of the head that is glued and tied to the skyrocket body. The other end of the cone has a diameter equal to 1-1/2 times the O.D. of the rocket body. The cone's height should be two times the rocket's O.D. The tip is merely a stubby cone that is glued onto the top of the truncated one. Its height should be 1-1/2 times the rocket's O.D. (see diagram L-106A-1).

Ignition: Black match, priming.

Materials: Twine, a stick to guide the rocket in a straight course. The stick should be about three times the length of the entire rocket, including its head.

Tools: Good skyrocket tools are an absolute necessity. They may be made of hardwood but the best ones are made of a non-sparking metal such as aluminum. They consist of a spindle and a series of drifts perforated ram rods), as shown, and with the following dimensions Taking the I.D. of the skyrocket as 1, tools for all sizes should measure as shown in figure L-106A-2.

(L-106A)
ROCKETS

Figure L106A-1 Sky rocket spindle

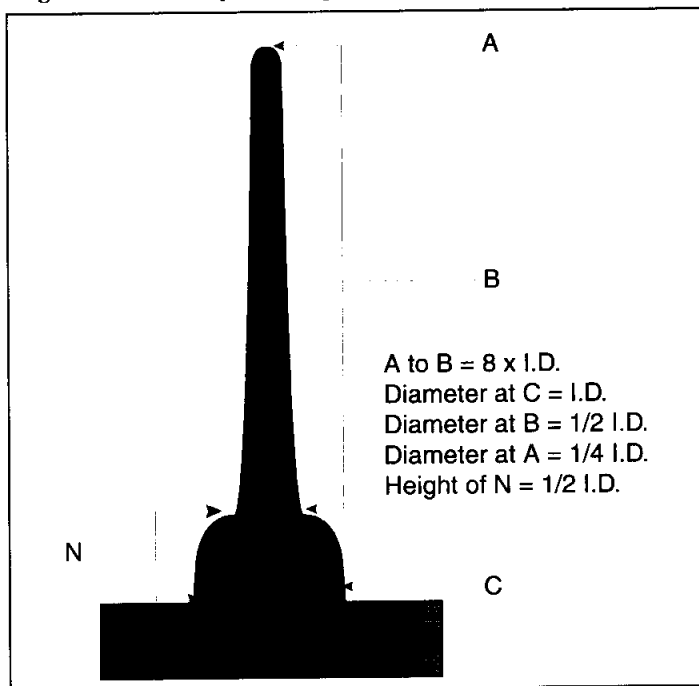
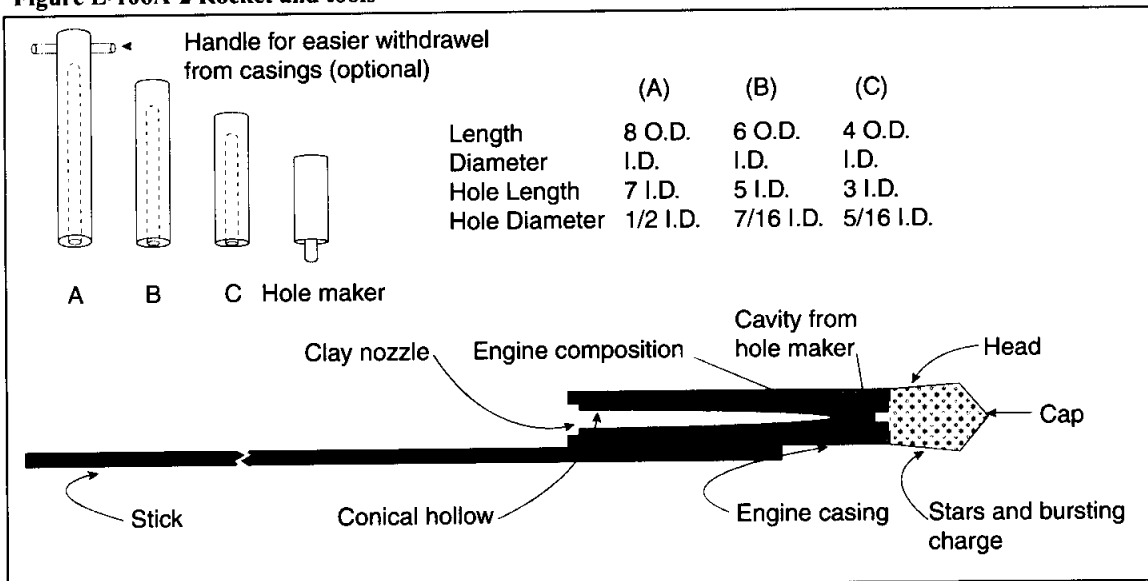


Figure L-106A-2 Rocket and tools



Note: Measuring scoops and Hole Makers are very helpful in constructing skyrockets.

Manipulation and Procedure: Slip an engine casing over the spindle, pour in a scoop full of clay, insert the longest drift, and drive with eight good blows from a mallet (preferably of rawhide). After being consolidated, the clay should be about 1/2 to 2/3 of the I.D. in thickness. The whole quantity of clay should be poured into the casing at once, not in many small portions. The clay, after being driven, actually makes small grooves in the inner walls of the case, and these grooves hold the clay plug in place against the pressure which arises from the burning composition.

(L-106A)
ROCKETS

Now drive in small portions, the appropriate composition. Introduce just enough each time so when it is driven with about ten blows it rises about 1/2" inside the case. A measuring scoop is best so consistent measurements are made. This is repeated until the case is filled to about 1/2" from the top. Shift drifts as it becomes necessary to use those with smaller holes.

Pour in a scoop full of clay and ram solid using a Hole Making rammer. This extremely handy tool makes a hole through the clay plug at the same time it consolidates the clay. Gently twist the engine from the spindle.

Attach the desired head and fill with a garniture of stars, etc., and a bursting charge of FFFg black powder. The total weight of the heading (head + garniture + bursting charge) should not exceed 1/2 the weight of the loaded rocket engine. Wrap a turn of paper (decorative or plain) around the rocket engine so it extends past the nozzle end about 1" for a nosing.

Insert a length of black match into the entire length of the conical hollow, apply some priming to the nozzle, and twist the nosing around the match. Attach the stick about 2/3 the way up on the engine case with twine and glue and the skyrocket is completed.

Almost anything can be used for the garniture of the rocket heading. All types of stars, whistles, bees, firecrackers, salutes, smoke cartridges, serpents, etc. may be used. In addition, whistles or smoke cartridges can be attached to the side of the rocket to fire during the rocket's ascension.

B. Line Rockets (Flying Pigeons)

This is a very amusing piece of fireworks. It is made by securing two rockets, with their nozzles pointing in opposite directions, to an empty tube. The head of one rocket is connected to the nozzle of the other with quick match. A piece of #18 gauge wire is stretched between two posts. One end of the wire is first slipped through the empty tube forming the middle of the pigeon. On lighting the first rocket, the pigeon will run along the line until the other rocket ignites, which returns the pigeon to its starting point.

A more effective form of a pigeon is made from a vertical wheel. Four wheel cases are fastened to the rim and the same number of rockets are secured to the hub, two pointing each way. The pigeon starts with one of the wheel cases, the rear end of which is connected to one of the rockets. This in turn is matched to the second wheel case and that to the next rocket, pointing in the opposite direction, and so on to the end. Combinations of wheel cases and rockets firing at the same time, reversing wheels and rockets, are very effective.

C. Serpents.

These are miniature rockets (without sticks) that scoot rapidly along the ground and into the air. Table L-106A-2 lists the compositions.

Table L-106A-2 Serpent, and Saucisson compositions

Material	Serpents	Saucissons
Meal powder	6	4
Saltpeter	2	2
Sulfur, flour	1	1
Charcoal, dust	1	1
Charcoal (100 mesh)	1/2	1/2
Dextrin	1/4	1/4
Iron filings (40 mesh)	ad. lib	ad. lib.

*Coated with paraffin

Casings: Wet-rolled 1/4" to 5/16" I.D. x 2" to 5" long x 1/16" to 3/32" wall.

Tools: A special "driving board" to load the composition and form the nozzle is constructed as follows: drill a hole 5/16" deep and the same diameter as the serpent O.D. in a block of wood. In the exact center, drive in a 1/8" diameter nail about half its length. With nippers, snip off the nail even with the block of wood until only the nail in the center of the hole is left. Also needed is a rammer about 2" longer than the casing and of the same I.D. It has a 1/8" diameter x 5/16" long hole bored in the exact center on one end.

Manipulation and Procedure: Insert a casing into the driving board hole. Drive in a charge of clay about 1/4" deep, then load, in small portions, the remainder of the casing with composition. The clay and composition should be loaded as for skyrockets. Insert a length of safety fuse and nose.

BUZZ BOMBS (HELICOPTERS) (L-106B)

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(L-106B)
BUZZ BOMBS (HELICOPTERS)

I. INTRODUCTION

These are fireworks that begin to spin on the ground and then ascend rapidly in a spiral manner to a height of 100-125 feet, where they terminate with a loud report or a shooting star. Table L-106B-1 lists the composition to use for Buzz Bombs.

Table L-106B-1 Buzz Bomb composition

Material	Buzz Bombs
Meal powder	7
Saltpeter	8
Sulfur, flour	2
Charcoal, dust	1
Charcoal (100 mesh)	1
Dextrin	1/4
Iron filings (40 mesh)	0

*Coated with paraffin

II. BUZZ BOMB CONSTRUCTION

Casings: These are wet-rolled, parallel wound from .016" Imitation Pressboard to the following dimensions: 3/8" I.D. x 2-3/4" long x 3/32" wall. Regular pressboard is too oily. Only imitation can be used. Pressboard should be used, rather than other types of paper, such as Kraft which is not as durable. The whirling motion of the device throws and concentrates the dross of the burning composition towards the nozzle end. Unless the case is tightly wound from pressboard, the dross may burn through the casing.

Ignition: 3/32" safety fuse.

Materials: A piece of light gauge sheet aluminum (about .020") 5" long x 3/8" wide to form the wing of the Buzz Bomb; a short, strong rubber band.

Tools: Good Buzz Bomb tools are absolutely essential. They consist of two rammers and a base, as shown. One rammer must be tapered at one end. This is to form a conical cavity in the clay plug. These tools should be made of a non-sparking metal such as aluminum.

Manipulation and Procedure: Insert a casing into the ramming base. Pour in a scoop of clay, and using the straight rammer, ram very hard, using about a dozen good blows from a mallet (preferably of rawhide). The clay plug should be about .2" thick after ramming. Now pour in another scoop of clay, and using the taper rammer, ram very hard as before. The total plug thickness should be about .5" thick and should have the conical cavity as shown.

Dampen the composition, and using the straight rammer, ram very hard, using about 10 good blows for each portion. Pour in just enough composition in each portion so after the 10 blows, it has raised about 1/2" inside the case. Continue until the rammed composition is within 1/2" from the top of the case.

Place the loaded casing in a vice (the composition, should still be damp) and drill a 3/32" diameter hole through the casing, clay plug, and into the composition. The hole should be midway between the two ends of the conical cavity as shown. The fuse hole must go through the clay plug. If it went through the paper casing, the hole would be enlarged by the escaping gases and the device would not maintain an even propulsion throughout its flight. Insert a length of fuse and secure it with glue.

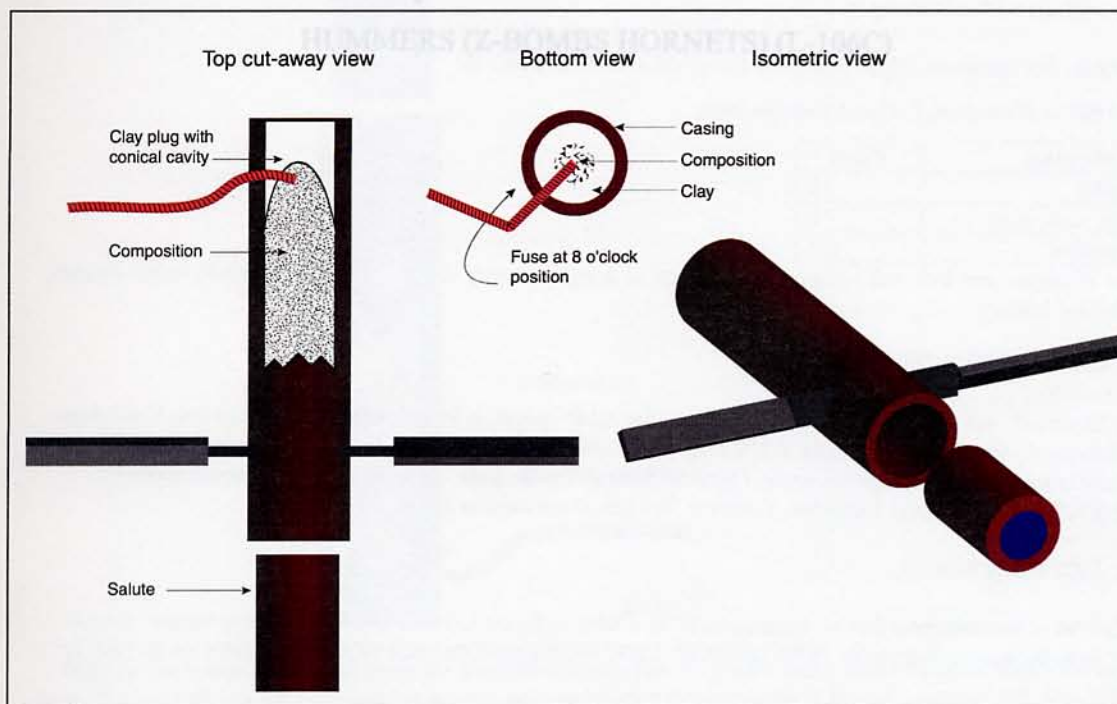
Now rotate the casing in the vice so the fuse is at the 8 o'clock position. Beginning at the 12 o'clock position and at the opposite end from the fuse, saw half-way through the casing just above the top of the composition until the saw reaches the 3-9 o'clock position. This forms a slot for the wing. Insert the wing evenly into the slot and secure with the rubber band. The upper edge of the wing, located on the same side of the case as the fuse, is twisted toward the fuse and the upper edge of the opposite wing is twisted toward the forward end of the case as shown. This provides the lifting effect.

Make a small salute (about 1" long) to fit snugly into the top of the Buzz Bomb. The end that fits into the Buzz Bomb should have a hole that is well primed. Instead of a salute, the Helicopter should have a 5/16" diameter star and a small blowing charge of meal or FFFFg powder. The star and powder are secured with a wad of paper and paste. Allow to dry about one week before firing.

(L-106B)
BUZZ BOMBS (HELICOPTERS)

When firing, lay flat on ground, fuse pointed toward the ground (approximately in the 8 o'clock position) as shown in figure L-106B-1.

Figure L-106B-1 Buzz bomb (Helicopter) illustration



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HUMMERS (Z-BOMBS HORNETS) (L-106C)

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(L-106C)
Hummers Z-Bombs and Hornets

I. INTRODUCTION

These are very amusing and unusual items. They are fired from a pipe or wire stand. Upon ignition they shoot rapidly up into the sky, spinning like a top and making a loud humming noise as they ascend. When they reach their apex they explode with a loud report.

Composition: For hummers and Z-Bombs is described in table L-106C-1.

Table L-106C-1 Hummer, Z-Bomb composition

Material	Parts
Meal powder	15
Aluminum, dark pyro	1
Dextrin, yellow	1/4

Note: The Hummer, and Z-Bomb compositions should be dampened very slightly (5%) with a 50:50 water: alcohol mixture before loading.

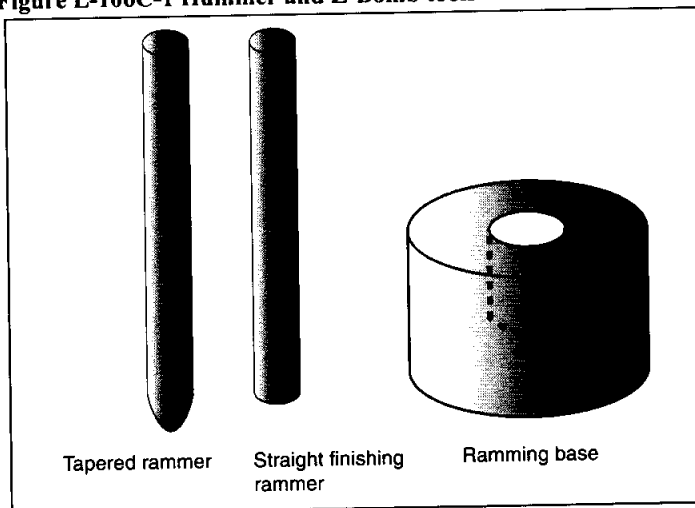
II. Z-BOMB CONSTRUCTION

Casings: These are* wet-rolled parallel wound from either .016" Imitation Pressboard or 73' Dura-Press Kraft paper to the following dimensions: 3 3/8" ID x 2-3/4" long x 9.16" O.D. Imitation Pressboard will give the better case, but this material is sometimes difficult to obtain. Only "imitation" can be used since regular pressboard is too oily. Duro-Press Kraft makes a good substitute, however. Try not to use regular Kraft.

Ignition: 3/32" safety fuse.

Tools: Consist of two rammers and an optional base, as shown in figure L-106C-1. One rammer is tapered at one end. This is to form a conical cavity in the clay plug. These tools should be made of a non-sparking metal such as aluminum.

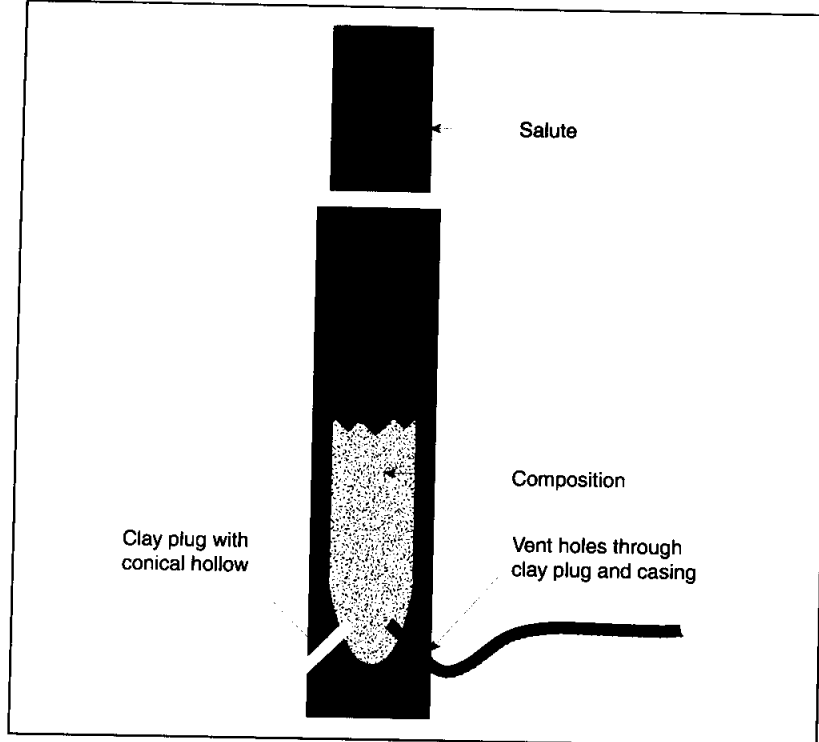
Figure L-106C-1 Hummer and Z-Bomb tools



Manipulation and Procedure: Insert a casing into the ramming base. Pour in a scoop of clay, and using the straight rammer, ram very hard using about a dozen good blows from a rawhide mallet. The clay plug should be about .2" thick after ramming. Now pour in another scoop of clay, and using the tapered rammer, ram very hard as before. The total plug thickness should be about 0.5" thick and should have a Conical cavity as shown in figure L-106C-2.

(L-106C)
Hummers Z-Bombs and Hornets

Figure L-106C-2 Z-Bomb detail

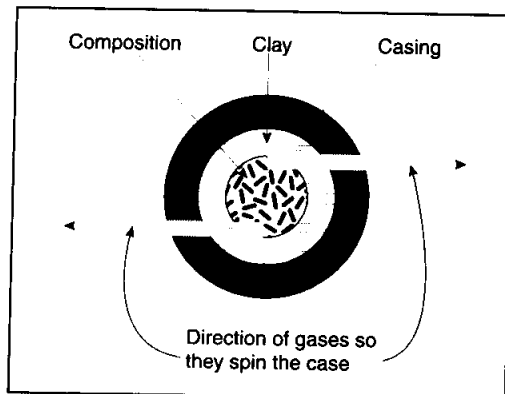


Dampen the composition, and using the straight rammer, ram very hard using about 10 good blows for each portion. Pour in just enough composition in each portion so after the 10 blows, it has raised about 1/2" inside the case. Continue until the rammed composition is within 1/2" from the top of the case.

Place the loaded case in a vice (the composition should still be damp) and drill 2, 1/8" diameter holes on either side of the casing, upward at a 60° angle through the casing's clay plug, and into the composition. The two holes should be midway between the two ends of the conical cavity as shown as for the Buzz Bomb. The holes must go through the clay plug so they can't be widened by the escaping gases. The holes must be bored so the gases will spin the case (to give the humming sound) and also propel it upward. Refer to figure L-106C-3.

Insert a small salute, as for the Buzz Bomb. Allow to dry about one week. It must be launched from a pipe, wire frame, or other launcher to start it upward on a straight course.

Figure L-106C-3 Detail view of jet holes in Z-Bomb casing



It requires considerable skill and experience to make these items since there are very many snags. The composition must burn just right. If too fierce, it may be slowed by reducing the meal powder to 12 parts and. or adding charcoal dust. The composition must be especially well consolidated. The hole must be of the right size and angle. The casing must be thick walled and hard to withstand the tremendous pressures, but yet be light weight. It

(L-106C)
Hummers Z-Bombs and Hornets

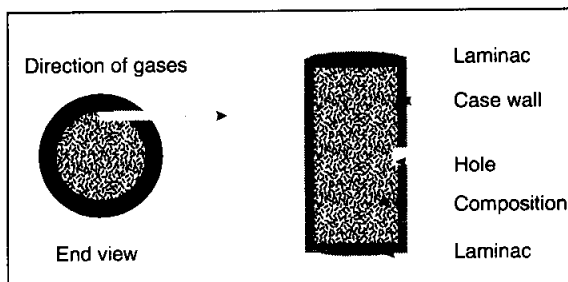
must be launched correctly. Thus, it may be necessary to do some experimentation in order to adjust all of these factors to your own particular techniques.

III. HUMMER CONSTRUCTION

Hummers are small humming devices that are very popular in aerial shells or in Roman candles. They function essentially the same as the larger Z-Bombs and can be made about any size. A popular size is 5/16" I.D. x 9/16" O.D x 7/8" long. Refer to figure L-106C-4.

They use the same composition, but are made a little differently. The case is first placed on a firm surface and the composition rammed in, in small increments until it reaches as close to the top of the case as you can get it. A thick slurry of Laminac and Chemite is then smeared on each and allowed to harden. A 3/32" diameter hole is then carefully drilled in the side of the case as shown so the escaping gases will make the casing spin. Insert a small piece of match and prime. If Laminac and Chemite are difficult to obtain, any Polyester resin can be used with a thickening agent.

Figure L-106C-4 Hummer construction detail



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TOURBILLIONS (L-106D)

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(L-106D)
TOURBILLIONS

I. INTRODUCTION

A tourbillion, so called from the French word for whirlwind, is a device that rotates and ascends at the same time, forming a spiral of fire about 100' in height. It terminates with a hemispherical canopy of sparks in the shape of an umbrella.

II. COMPSITION FORMULAS

Composition: Is described in table L-106C-1.

Table L-106C-1 Tourbillion compositions

Compositions:	Formula (1)	Formula (2)
Potassium Nitrate, powder	22	75
Sulfur	13	10
Charcoal, willow dust	13	15
Meal Powder	52	-
Dextrin	2	2
Iron Filings or Titanium	ad lib	ad lib

Note: all parts by weight

Formula (1) is the faster burning of the two. Both may be made to burn slower by the addition of charcoal dust. Or for added sparks, 100 mesh, 40 mesh, or 20 mesh charcoal may be added. Burn rate may be increased with the addition of meal powder. Steel or iron filings may be added as desired, but both should be coated with paraffin or linseed oil to protect them from being oxidized by the saltpeter or meal powder.

Casings: The best size is 3/4" I.D x 7-1/2" long x 1-1/8" O.D. These should be wet-rolled from very strong paper and rolled as tightly as possible. Machine rolled cases made from Dura-press Kroft paper available from Westech are ideal.

Tools: This is merely round dowel of non-sparking metal or wood 3/4" diameter and about 9" long. Also required is a 3/16" diameter bit and drill.

III. TOURBILLION CONSTRUCTION

Manipulation & Procedure: Place the casing upright on a firm base and ram a plug of clay 1/2" thick. Now pour in a scoop full of composition and ram tightly with about 10 good blows with a rawhide mallet. Continue ramming one scoop full at a time until 1/2" from the top. Ram in a plug of clay about 1/2" thick to finish. The composition should be dampened with about 5% water and rammed damp.

Now find the balance point by placing the device on a knife edge and mark this point on the case. Measure 1-1/2" on either side of this point and in a straight line with the long axis of the case. Bore a hole with the 3/16" bit at these points. The holes should be bored slowly and about half-way into the composition. Special care must be used when boring so as not to ignite the composition from friction. Now bore a hole at each end, opposite to one another, but both being 90 degrees from the first two holes, as seen in illustration figure L-106D-1.

Now prime the holes, and while still wet, match by taping (masking tape) a piece of black match to one of the bottom holes, passing it to the nearest end hole, then over the top to the other end hole and finally to the other bottom hole. Use tape as necessary. Now cover the device with a piece of 30# Kraft, pasted on both sides. Use enough Kraft to cover the device end-to-end and form two complete turns. This operation covers the black match, converting it to quick match, and protects the device from premature ignition from stray sparks. Allow to dry before proceeding with the next step.

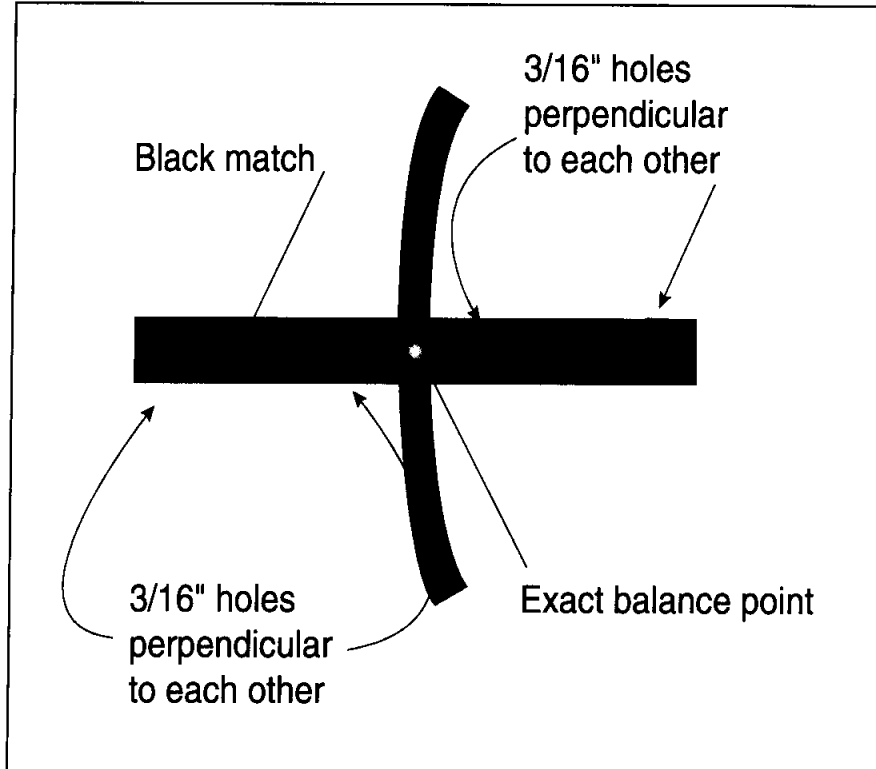
A curved stick, 7-1/2"-long x 1/2"-wide x 3/16" thick, is nailed to the bottom of the case, the concave side against the case. It should be nailed between the two bottom holes and at right angles to the case, using a nail as long as possible without letting it come through the case on the opposite side. Tourbillion sticks can be easily made from wood obtained from orange crates or other fruit cases. Cut the correct size and then bend it by heating the middle over a candle flame and bending upwards on the ends at the same time. When cool, the stick will stay bent. Bend only as far as the stick will go without breaking, of course. The stick does not have to be bent much to work.

(L-106D)
TOURBILLIONS

Now poke a hole through the Kraft paper wrapping near one of the end holes, insert a piece of safety fuse and tape in place so it will ignite the piece of black match inside.

Tourbillions are fired by laying them on a smooth surface, stick down. Fancy display tourbillions may be made by the addition of a few stars in each end of the case, outside of the clay, boring a small hole through it, adding a little gunpowder and securing the top with strong paper and a wad.

Figure L-106D-1 Tourbillion detail



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NOVELTY FIREWORKS (L-107)

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(L-107)
NOVELTY FIREWORKS

I. INTRODUCTION

Most of these fireworks are miniatures of their larger display counterparts. Some are unique items in themselves and are only made in the small size described here. Since all of these fireworks are quite small, they have sometimes been called "children's fireworks." However, there are some items that have more than uncommonly dangerous compositions. Therefore, all safety precautions given in this treatise must be followed to the letter.

Certain principles and pyrotechnic theory are also included so the pyrotechnist can better understand the processes that are involved in making these fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanisms necessary for proper function are described. Fourth, any special materials (items that neither make up part of the composition nor the casing nor the ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. COMPOSITION FORMULAS

Table L-107-1 Novelty fireworks compositions

Material	Pinwheels	Bottle Rockets	Sparklers	Bees
Meal powder				12
Saltpeter	17	18	20	
Sulfur, flour	3	3	4	
Charcoal, dust	2	2-6	6	
Charcoal, coarse	2			
*Iron, filings (40 mesh)	6		8	
Aluminum, dark pyro		1/2	1	1

*Coated with paraffin.

Table L-107-2 Fire stick and smoke compositions

Fire Sticks	Emerald	Ruby	Smokes	Yellow	Olive	White
Potassium Perchlorate		2	Meal powder		1	
Strontium Nitrate		6	Saltpeter	5	1	12
Barium Chlorate	4		Sulfur, flour	2	1	16
Aluminum, bright pyro	6	6	Antimony Sulfide,		1	
Shellac	1	1				
			Arsenic Sulfide, red	3	1	
			Charcoal, dust			1

Note: All parts by weight.

III. PRODUCTS OF MANUFACTURE

A. Pinwheels

Casings: These are made from four turns of dry rolled Kraft paper, about 1/4" I.D. x 12" to 24" long.

Ignition: Chinese fuse or safety fuse, priming.

Materials: A piece of thin chipboard cut in a 1 1/2" diameter circle with a small hole in its exact center; glue.

Tools: A circular plate of plastic or metal about 1/8" thick, cut in the same diameter as the above cardboard circle; a large board with 1/4" square strips of wood nailed to it, the same distance apart as the width of the finished pinwheel.

Manipulation and Procedure: Twist the ends closed of a number of casings, tie them loosely into a bundle and stand them upright on a large sheet of paper with the open ends up. Pour in the composition until all the tubes are full. Jolt the bundle occasionally so that none of the tubes is only partly filled. Twist the tops closed, spread them loosely on the wet towel and roll it up so each pipe will touch a part of the wet cloth. Set aside in a damp place for several hours. The tubes should be thoroughly moistened, but not too wet, before proceeding further. When this condition has been reached, press them with a rolling pin so that they will be somewhat flattened. The exact amount of flattening can only be ascertained by experiment. Fasten the circular plate of metal or plastic to the work table. Lay the circular piece of chipboard on this and, taking a filled pinwheel tube, press one end against the edge. Twisting it around the disc, continue until all the tube is rolled around the center. The circular plate should be half as thick as the finished pinwheel so that the cardboard center will be held just in the center of the finished pinwheel, while it is being twisted. When the wet tube is all twisted on, lift it off the circular plate and set it between two of the 1/4" strips of wood on the board so as to keep it from untwisting. Brush on some glue across the pipes and onto the center disc at four equidistant points. When dry, the pinwheels may be removed from the board and matched, ready for use.

B. Bottle Rockets

There are two kinds of bottle rockets (so named because they are launched from soda pop bottles). One type of bottle rocket ends with a report; the other does not.

Casings: These are wet rolled from newspaper: 3/16", I. D. x 1 1/2" long x 1/32" wall.

Ignition: Chinese fuse or safety fuse.

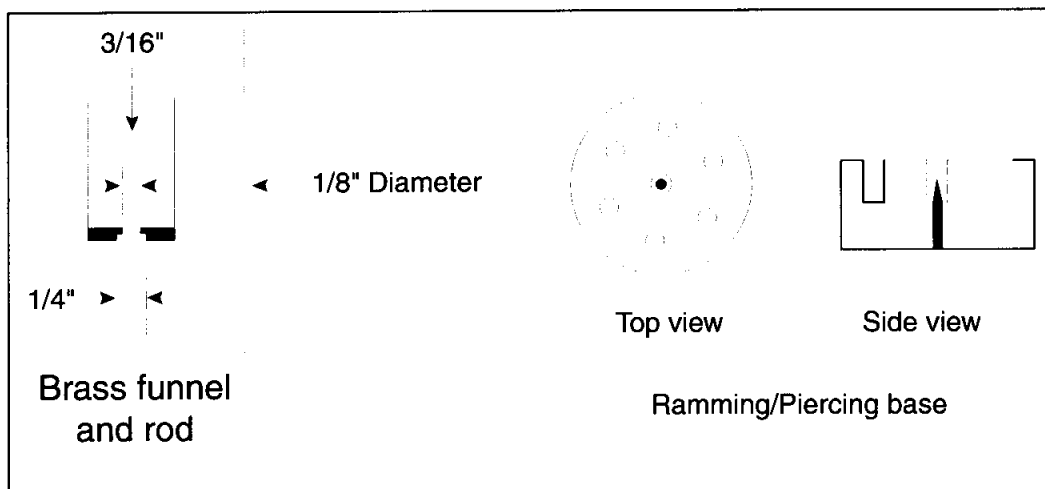
Materials: Clay, a thin stick made of balsa or bamboo to guide the rocket, with the following dimensions: 6" to 10" long x 1/16" or less.

Tools: These consist of two parts: A "funnel and rod" and a "ramming/piercing base." The funnel and rod are made from aluminum as shown. It has a shoulder that allows it to fit over the casing for easier filling. The ramming/piercer base is constructed from a piece of 2" diameter x 1" aluminum. Around the periphery are bored six 1/4" diameter x 1/2" holes. In the center is another hole (same dimensions) but in its exact center is a sharp, steel piercer, 3/32" diameter at its base and tapering to a point. It extends inside the hole about 1/4". (The base may be made from hardwood, if desired.)

Manipulation and Procedure: Insert casings in each of the peripheral holes in the base. Fill the funnel half full of clay (the rod should already be in the hole) and with a rapid and hard up-and-down motion on the rod, drive in some clay in each of the cases so they each have a hard, 3/32" thick clay plug. Now half fill the funnel with composition and fill each of the casings to within 1/4" of the top of each case. Now push each filled casing all the way to the bottom of the center hole so the piercer forms the exhaust vent through the clay plug and partially into the composition. If the rocket is to finish with a report, fill the remainder of the case with flash powder and seal with a wad of tissue paper and glue. Attach the stick by rolling it and the case in a turn or two of paper. Prime the vent and insert a fuse. The same piece of paper that holds the stick can act as a nosing if twisted around the fuse.

(L-107)
NOVELTY FIREWORKS

Figure L-107-1 Bottle rocket tools



C. Flying Discs

These are the miniature versions of the tourbillon. Upon ignition, they spin rapidly into the air to a height of about 50 feet throwing sparks in all directions.

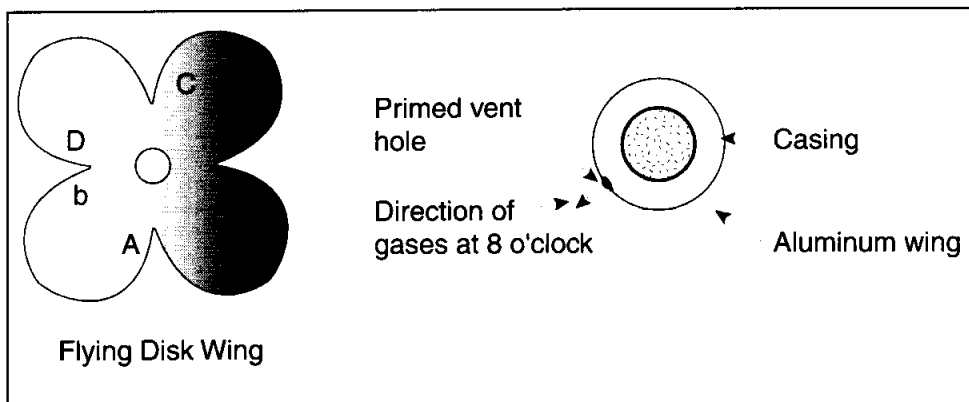
Composition: Same as for bottle rockets except add 1/2 part aluminum flitters.

Casings: Same as for bottle rockets.

Ignition: Ditto

Materials: Prof. Pyro. Ad., a piece of very thin gauge aluminum about .020" thick, cut in the following pattern:

Figure L-107-2 Flying disk illustration



After cutting out the wing from the sheet of aluminum, bend along the dotted lines at A, B~ C, and D upward in the direction of the arrows, so each little clover leaf is at about a 30 degree angle with the horizontal. Now take a round nosed punch and make a small indentation downward in the center of the wing (shown by the circle in the diagram). This indentation forms a small pivot on which the wing can revolve before it ascends.

Tools: Same as for Bottle Rockets.

Manipulation and Procedure: Plug and fill the casings as directed under Bottle Rockets. Smear a drop of glue the 1/4" space to cover the powder. If the Disc is to end with a report, proceed as above.

Now drill a 3/32" bole through one wall and into the composition, just above the clay plug. Prime the hole and insert a fuse. With small dabs of Adhesive, attach the filled casings to the wing in a straight line between "a" and "b" (see figure L107-2). The vent hole and fuse should point so the gases shoot downward at about 8 o'clock, just underneath the wing at point "D".

(L-107)
NOVELTY FIREWORKS

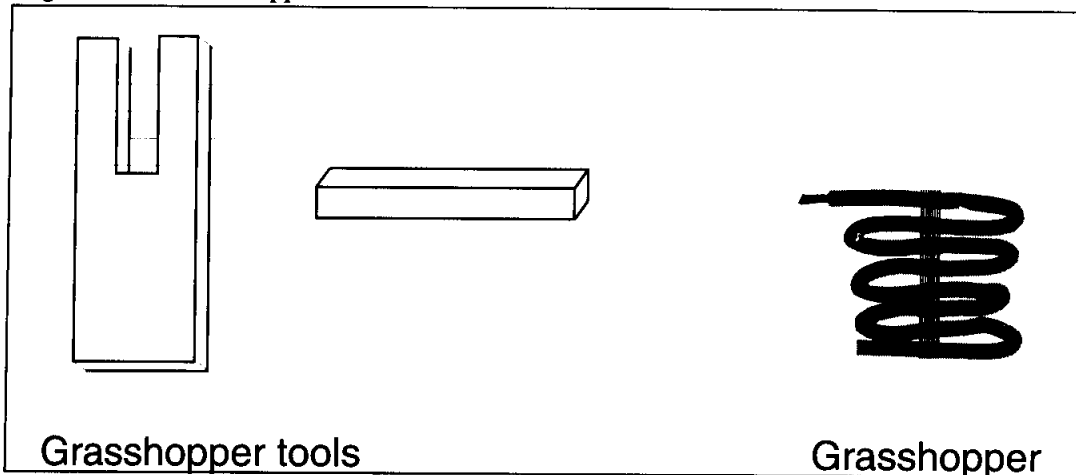
D. Grasshoppers (English Crackers)

These delightful novelties are one of the most amusing pieces of fireworks that can be made. They hop, pop, crack, and jump all over the place, all the while shooting sparks and smoke.

Composition, Casings, Ignition: Quick match (with close fitting pipes).

Tools: These are made from wood, as shown. The notched piece is 1" thick x 18" x 4" wide. The notch is 1-1/2" wide x 6" deep. The solid piece is about 1" square x 10" long. Also needed are 12 pieces of stiff wire, 4" long. These may be cut from a common wire clothes hanger.

Figure L-107-3 Grasshopper tools



Manipulation and Procedure: Cut the quick match into 15 inch lengths. One half of the bare match is withdrawn from one end of the pipe while the other is twisted closed. A bundle of these is now wrapped in a wet towel and set aside for several hours to soften. The cloth should be dampened well and the tubes so rolled up in it that each one touches a part of the damp cloth. The tubes should be thoroughly moistened, but not too wet, before proceeding further. When the pipes have become so damp that they will not tear when bent at right angles, they are folded as follows. Lay the twisted ends of a dozen of the damp pipes across the bottom of the notched board which has been fastened in an upright position to a bench. On top of these and against one side of the board lay a wire and bend the pipes over it until they now point in the opposite direction. Lay another wire as before but on the opposite side and repeat the operation until the entire length of pipes has been folded up.

Now take the solid piece of wood and holding one end in each hand, press the folded pipes down as hard as possible so the turns will be well formed. Now lift out the folded bunch, wires and all. Remove the wires, and one-by-one secure the pipes in their folded condition by wrapping a half dozen turns of light string or shoemakers' linen around the bunch and a few turns between the folds. When dry, grasshoppers are ready for use.

E. Bees

These items shoot around in all directions with a loud humming sound. They may also be shot from mortars, or used to fill an aerial shell.

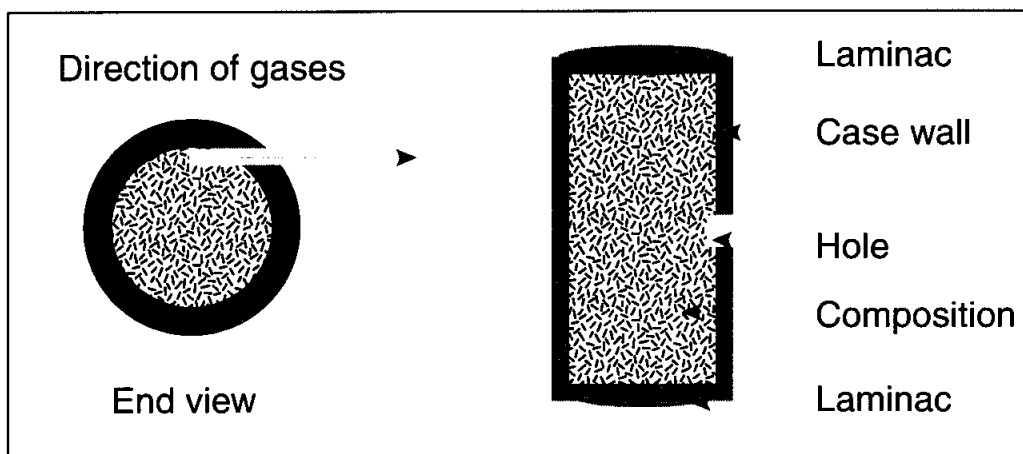
Casings: These are very important. They must be thick walled and very hard in order to function properly. They are wet rolled from Kraft paper: 5/16" I.D. x 1-1/4" long x 9/16" O.D.

Ignition: Safety fuse and/or priming.

Tools: A rammer the same diameter as the I.D. and 2-1/4" long.

Manipulation and procedure: Place the casing on a firm surface and drive in some clay so a 1/4" thick plug is formed. Drive in the composition, in small portions, until within 1/4" from the top. Drive in another 1/4", plug of clay. Now drill a 3/32" hole in the center of the casing and barely into the composition. This hole must be driven at the angle shown in the diagram so the escaping gases will make the casing spin. Prime and insert a length of safety fuse.

Figure L-107-3 Bees



F. Sparklers

These are easily made by adding enough composition to some shellac solution to make a very thick mixture that will adhere to the wires. Stiff pieces of wire are then dipped into this mass and allowed to dry. The dipping time(s) vary; only experimentation will give good results.

G. Fire Sticks

These are thin wooden sticks similar to the applicators used by physicians for applying iodine, etc. They are dipped for half their length into the composition given. Dissolve the shellac in alcohol and add the other ingredients, previously well mixed. Stir thoroughly to a consistency of thick glue and dip the sticks. Allow to dry.

H. Smoke Pots

These are easily made by driving a smoke composition into any size casing with a clay plug at one end. When the casing is full of composition, prime, match, and nose.

I. Smoking Cap Stick

When lit, these produce a small stream of smoke for several seconds, then end with a loud bang. These are quickly made by dry-rolling a piece of newspaper 3-3/8" long into a tube with a 1/8", I.D. and 1/4" O.D. Pack damp clay into the tube to form a plug 1/4" thick. The top of this plug should be about 3/4" from the top of the tube. Now pack a very small quantity (1 grain or less) of wet picric acid into the tube. Ram the rest of the tube full with the white smoke composition. Prime, match, and nose.

J. Cracker Balls

These are miniature torpedoes, exploding when they are thrown against a hard surface. They are made by mixing 1 grain of Potassium Chlorate with 1 grain of Red Arsenic Sulfide, and then adding 6 grains of small, sharp edged gravel. Wrap this up in a 1" square piece of Gampi tissue paper. Add a thin layer of paste to the outside and form into a small 3/8" diameter ball. Add more Gampi and paste if necessary. Allow to dry for about 1 week. NOTE: This is an extremely sensitive mixture to shock and friction.

Be very careful and gentle when mixing and loading. It is best to add some pure methyl or ethyl alcohol to dampen the Potassium Chlorate after it is weighed out but before it is mixed with the Arsenic Sulfide. When damp, the mixture is fairly safe. Do not dampen with water. Water will make the mixture too sensitive to use after it dries out. This is why rubbing alcohol should not be used to dampen the mix. Rubbing alcohol contains about 30% water. Only pure, 100% alcohol should be used. Do not throw near any person since the gravel is impelled with considerable force, and could cause serious injury. The manufacture of these items are not recommended for beginners.

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PROFESSIONAL PYROTECHNIC ADHESIVE (L-TR1)

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(L-TR1)
PROFESSIONAL PYROTECHNIC ADHESIVE

I. INTRODUCTION

This particular item is one of the most useful and versatile that the pyrotechnist has at his disposal. Its composition has long been kept secret from the general public. Its advantages are:

- an extremely strong adhesive;
- dries very rapidly;
- easy, quick, and inexpensive to prepare,
- can be made to any consistency desired.

Some of its main uses are:

- attaching the paper mortars to wooden bases in making aerial star shells, comets, mines, etc.
- securing and reinforcing the paper end plugs used in the salutes;
- forming the outer rock-like shell of Cherry Bombs;
- plugging the ends of repeating aerial salutes,
- as the main adhesive of and for finishing aerial display shells and salutes;
- attaching drivers, gerbs, etc. , and fortifying their junctures on wheels, revolving pieces, and other display items.

II. PREPARATION

To prepare this professional adhesive the following items are needed:

- Calcium Carbonate (whiting, precipitated chalk).
- Zinc Oxide (zinc white).
- Sodium Silicate (water-glass).

Calcium Carbonate and Zinc Oxide can be obtained from dealers in painters supplies, hardware stores, etc. They can also be purchased from drug stores, but at a more expensive price. One pound of each is a good starting supply.

Sodium Silicate is the "water-glass" used as an egg preservative. It is sold at drug stores or chemical supply houses. Make sure it is the thick, syrupy kind, not the thinned-down solution used as a label adhesive. One quart is a good supply. All three of these chemicals can be obtained very inexpensively from Westech.

Mix two parts Calcium Carbonate with two parts Zinc Oxide and to this add one or more parts Sodium Silicate, depending on how thick the Adhesive has to be. Stir well until a smooth texture is obtained. This Adhesive can be made without Zinc Oxide, substituting additional parts of Calcium Carbonate instead. The advantage to this is that the Adhesive is less expensive; however, it is somewhat less strong.

Make only enough Adhesive for immediate use as the unused portion cannot be stored, since it hardens within an hour or two. All utensils used in making or applying this Adhesive should be promptly cleaned with water, since once the Adhesive dries on something it cannot readily be removed.

The Adhesive can be tinted any color by the addition of a dry pigment such as that used to color cement or water color paint powder.

To form the outer shell of Cherry Bombs, the Adhesive is modified somewhat. Mix the Adhesive to a medium consistency. Add to this some red coloring agent and some very fine sawdust. Then, holding the Cherry Bomb by the fuse, dip it into the Adhesive/sawdust mixture. One coating should be enough.

HINTS FOR PROFESSIONAL QUALITY SALUTES (L-TR2)

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(L-TR2)
HINTS FOR PROFESSIONAL QUALITY SALUTES

I. INTRODUCTION

There are four main factors that produce better quality exploding fireworks. The type of aluminum used; the particle size of Potassium Perchlorate; the thoroughness of the mixing of the composition; and the degree of compaction of the composition in the casing. There are also two other factors: the strength of the casing; and the size and placement of fuse.

II. MAJOR FACTORS

The main secret to this formula is the black German pyro aluminum. The reasons that this type works so well are that it is completely free of grease and stearates that would, if present, slow the combustibility; and the extremely fine mesh (400 and finer) greatly increases the combustibility. Being such, it is very sensitive, in fact explosive even to static electricity, when dispersed in the air during the mixing process. All other types of aluminum, including the best domestic "dark pyro" grades, are not as free from the stearates and other impurities, and are not as finely powdered, being about 325 mesh. The black (sometime called "dark") German pyro aluminum looks almost exactly like black Antimony Sulfide.

The Potassium Perchlorate must be finely powdered, about as fine as powdered sugar. Most material when purchased is somewhat granular. Even the types advertised as "powder" should be ground with a mortar and pestle (or powdered by other means) until it is about like powdered sugar. Though a good report can still be obtained using material that is not this finely powdered (and some commercial manufacturers do use less finely powdered material for economical reasons), better results are obtained by using the finely powdered material.

The more thoroughly the components are mixed, the louder will be the report. This is another factor that some commercial manufacturers, again for economical reasons, do not observe very thoroughly. As a result of this and the previous factor, their salutes carry much more composition (poorly mixed, with large particle sizes, and sometimes using more dangerous ingredients such as chlorates) to make the same size report as would be necessary if a composition were used whose ingredients were properly mixed and of small particle size.

Extreme caution must be exercised when mixing this composition. Only small quantities (not more than one or two grams) should be mixed at one time. A very safe and adequate method of mixing this composition is to separately introduce the ingredients into the casings and then mix. First, pour the requisite amount of Potassium Perchlorate (and Chemite, see below) into an individual casing. Then pour in the aluminum. Leave unmixed. Plug the remaining open end of the casing (allow to dry if necessary). When dry, a number of these may be placed in a cardboard box and tumbled by rotating the box so as to mix the ingredients. In this way, there is not a large quantity of explosive composition in any one place. In fact, there is no explosive composition until the ingredients are mixed inside the casing.

Flash powder must be loose to give maximum results. Thus, salute casings must only be partially filled, about 80%. The theory behind flash powder being loose is to increase the ignitable surface area of the powder. In the past, such materials as sawdust, bran, barley hulls, and other "bulking agents" were used to affect this. The modern (less expensive and more effective) way to achieve this is to use "Chemite." See the catalog for a complete description of this material. Chemite aids in increasing the surface area of the salute powder so more can be ignited at the same time. The more area that can be exposed for a given volume and time, the greater will be the report. Thus, it is possible to produce the same size report using less powder which is more exposed than using more powder but which is less exposed. The salute is thereby made safer by producing an equal report but with less destructive force. And, since less powder is used, salutes are also more economical than those needing more powder to produce the same report.

(L-TR2)
HINTS FOR PROFESSIONAL QUALITY SALUTES

III. OTHER FACTORS

The stronger the case, the louder will be the report. This is why end plugs and fuse holes should be adequately secured or reinforced. Professional Pyrotechnic Adhesive (L-TR1) is best. Under no circumstances should metal, glass, pieces of wood, cement, or other unyielding substances be used as parts of casings. Only paper should be used, since when properly constructed, paper casings are as strong as metal but are able to be fragmented into harmless bits of paper.

As stated above, the more flash powder that can be ignited in a given time, the greater will be the report. Thus, a larger fuse and its placement in the middle of the composition will give an increased report (A middle placed fuse starts the powder burning towards the two ends; if placed at one end, the fuse would start the powder burning only at one end.) Also, if the tip of the fuse that ignites the powder is given a thick coat of priming (meal powder, dextrin and water made into a thick paste), this will further increase the report since more powder will be ignited in less time. The priming can best be added after the fuse is inserted in the empty case. Allow to dry completely before adding any flash powder. Never punch a fuse hole in a case that already is filled with composition.

These points, though simple, make the difference in producing professional quality salutes. The use of only a certain type of aluminum or other ingredients; the special particle size (usually very small) of these ingredients; and their thorough mixing constitute the great part of the "art" and most of the "secrets" of pyrotechnics.

IV. COMPOSITION FLASH FORMULA

Table L-TR2-1 Flash salute formula

Composition	Parts by weight
Aluminum, black German pyro	3
Potassium Perchlorate	7

ROUND STARS (L-TR3)

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(L-TR3)
ROUND STARS

I. INTRODUCTION

Round stars are based on the simple principle of building up successive layers around a central core. Although this may seem obvious, the exact way of doing this has long remained a mystery to Western fireworks makers. The secret is to add dry material to a damp core.

There are two types of round stars. Both types are made using the above principle. The first type uses a small seed, or other very small, round object as the core. The second type uses a small, cut star as the core. This type is usually used in the manufacture of color changing stars.

II. MANIPULATION AND PROCEDURE

Type I

The Japanese use small, round seeds, or other small objects such as buckshot to act as the core. The small (about 1/16" diameter) candies used as cake or cookie decorations work very well. Whatever core is used, pour a quantity of them into an ordinary mixing bowl, dampen them slightly with water sprayed from an atomizer. Now sprinkle some dry star composition over the dampened cores and rotate the bowl rapidly, so the cores swirl around, picking up the composition evenly on their surfaces. When it appears that all the composition has been picked up, dampen the now miniature stars as before, sprinkle on more composition, and rotate the bowl again. This process is continued until the stars are the desired size.

Do not spray the sides of the bowl with water when dampening the cores, since they will adhere to anything wet. Try to keep the sides as dry as possible at all times. If the sides become too damp, the dry composition will build up on them due to the rolling action of the cores, instead of on the cores themselves. The correct amount of dampening will come only with practice. The amount of dry composition to be added also can be ascertained by experience. Add enough each time so all of it is picked up by the cores and none is left in the bowl. Of course, more will have to be added each successive time.

Type II

The same process is followed, but instead of small, round cores, cut stars are used. The cut stars must be exactly cubical or the resulting star will not be round. The cut stars may either be used immediately after they are cut while they are still damp or they may be already dry and then sprayed damp as explained above.

To make color changing stars, simply start with a cut star of one color, dampen, and use dry composition of another color. Or, just change composition once a layer of one color is sufficiently thick. The exact thickness must be found by experience, since it depends on the type of composition being used, size of star, placement in relation to the outside of the star, and other factors. Each color should burn long enough so a definite color can be observed.

PETARDS (L-TR3A)

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**(L-TR3A)
PETARDS**

I. INTRODUCTION

Although simple in construction, Petards are extremely effective. The whole secret is in the composition shown in table L-TR3A-1.

Table L-TR3A-1 Petard composition

Material	Parts by weight
Potassium Chlorate	66
Aluminum, dark	34
Chemite	1

Most of the success depends upon the type of aluminum used. The dark pyro aluminum available from Westech is the only suitable type since it meets military specs. (The black German type can also be used.) Powder the chlorate thoroughly and then mix completely with the Chemite. Now mix in the aluminum. Not absolutely necessary, Chemite adds tremendously to the effectiveness of the composition. Since this formula contains a chlorate and aluminum together, it is **EXTREMELY SENSITIVE TO FLAME AND STATIC ELECTRICITY**. It should also not be subjected to rough handling or friction. It will, however, withstand the shock of a bursting charge (or lifting charge) of an aerial shell. Petards are much used in Italian-type aerial shells where multiple salutes are needed.

II PETARD CONSTRUCTION

Construction of Petards is as follows. Roll at least four or five turns of Kraft of newspaper around a suitable former. Pull the former slightly out so the end of the paper tube can be folded and pressed down against the end of the former and secured with tape. Now withdraw the former completely. Insert a piece of good, stiff match into the care, then pour in some composition. The match should lay along side the inside of the case and extend for the whole length of the case plus an inch or so outside. Now firmly press in sawdust on top of the composition. The sawdust should be dry, and free from as much oil and turpentine as possible. The amount of sawdust depends on the length of delay you wish before the black match ignites the composition. Whatever the amount decided upon, when it is pressed in there should be enough empty casing left so it can be folded over the sawdust and match and secured in place with some masking tape. The Petard is now complete.

III. HINTS

There should be at least an inch of match protruding from the device to assure it takes fire from the burst charge of an aerial shell, rocket, etc. When made correctly, these devices never fail to take fire and explode with a tremendous report notwithstanding their very light construction.

Of course, Petards can be made without black match and delay sawdust by first taping the first end shut as before. Then poke a hole in the side of the casing and insert a length of safety fuse. Fill with composition and fold and tape the other end shut. Instead of going in the side, the fuse can also go in one of the ends.

Petards use a composition that does not have to be loose to give a good report. In fact, the composition can be tightly packed and still function very well. A well made Petard should have the composition and sawdust packed so that when the side of the device is squeezed or pressed it feels very firm and tight to the touch.

The casing should have enough turns of paper (the more turns, the louder the report) and should be very tightly sealed at each end so they do not explode prematurely from the flash of the bursting charge, or from sparks from other sources.

PYRO POWDER (L-TR4)

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(L-TR4)
PYRO POWDER

I. INTRODUCTION

Much of the success of the powder depends on the physical state of the ingredients, especially the charcoal. It should be made of willow or other soft wood, and must be as finely powdered as possible. The smallest, particle size available is the type known as "air-floated." This material is ideal. The oxidizer(s) should be as fine as powdered sugar or flour. The same holds true for the dextrin and lactose. Sucrose, common table or confectioners sugar is quite unstable and undependable with a chlorate. Its use is not recommended.

Table L-TR4-1 Composition formulas

Materials	#1	#2
Potassium Chlorate	77	33
Charcoal, dust	23	10
Dextrin, yellow	2	
Potassium Nitrate		33
Lactose		10

Formula #1 is a very quick-burning and powerful powder. Formula #2 is less powerful.

II. PRODUCTS OF MANUFACTURE

Once the ingredients have been carefully weighed, they should be thoroughly mixed, using 40 mesh mixing sieves. Pour the mixture into a tough, plastic bag and dampen slightly with water. Now comes probably the most important step. With the fingers, knead the powder through the bag until the water is thoroughly worked into the mixture. If necessary, add more water until the powder is just damp enough to stick together like wet sand. It should not be watery, pasty, or tacky. The water dissolves the oxidizer(s) so the porous charcoal is thoroughly permeated with it (them). The wetting also forms the dextrin or lactose into an adhesive which binds all the ingredients into closer contact. When thoroughly kneaded, dump the powder onto a dry, clean surface to dry. Use caution: when dry, the powder is highly flammable.

A. Meal powder

To make meal powder, break the larger pieces into a fine (100 mesh or less) powder. What actually results is a granulated powder of extremely fine particle size.

B. Granulated powder

To make granulated powders (equivalent to F to FFFF grades of black rifle powder), add slightly more water to the powder while in the bag and press into a firm ball. Now grate the damp powder through a wire screen of the desired mesh size. Enough water should be added to the granules so they do not crumble but retain their shape when grated. However, do not add too much water, since the excess cannot be absorbed and will only upset the correct ratio and distribution of the ingredients by causing the oxidizer(s) to crystallize out.

NOTE: Since these meal and granulated powders contain a chlorate, they must not be used in composition formulas that contain any sulfur, sulfides, or sulfates, etc.

C. Rice hull powder

Use regular meal or granulated powders, either commercially or self-made. To make a coarse powder such as the type used as a lifting charge (equivalent to FFF grade of blasting powder), coat the powder on rice hulls. This also makes a powder equivalent to the "rice-hull powder" used as a bursting charge in Japanese aerial shells. The only way to coat the hulls is to pour them into a bowl of water. Allow them to become thoroughly saturated with water (takes about 30 minutes). Drain off the excess water, dump the soaked hulls into a box or bowl, pour in some dry meal powder, and shake the whole lot until the powder is thinly, but completely and evenly coated on each of the hulls. It is easier if 2 or 3 small portions of powder are added, rather than one large portion. The rice hulls not only serve the purpose of granulation at a fraction of the time involved, but actually increase the effectiveness of the powder. This is because the rice hulls make a powder of lower density and greater surface area than granulated powder. Few available materials have the strength, low density, and great surface area to accomplish this as effectively and at such a low cost as rice hulls.

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"CHINESE" FUSE (L-TR5)

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(L-TR5)
"CHINESE" FUSE

I. INTRODUCTION

Paper: The main secret in making Chinese fuse is the use of a special oriental paper called Gampi tissue paper. This paper combines all of the qualities of malleability, tensile, and wet strengths needed to make good fuse.

Powder: The formula in table L-TR5 is a good one for fuse powder.

Table L-TR5-1 Fuse powder composition

Material	Parts by weight
Potassium Nitrate	6
Sulfur	1
Charcoal, dust	1
Dextrin	1/4
Aluminum, dust	ad lib

The Potassium Nitrate must be about as fine as powdered sugar. The "double refined powder" is best. The Charcoal must also be as fine as possible and be made from a soft wood such as willow. The "air-floated willow dust works best. Weigh accurately, and mix well (40 and 24 mesh mixing sieves are best). The resulting mixture can be used; however, a much more dependable fuse powder results if the mixture is placed in a ball mill (such as T-BMS or T-BML) and made into meal powder.

Tools: These consist of a "fuse board" which is a piece of smooth wood about 12" (or longer) x 2" wide. Also required is a "powder applicator" which is a metal tube, closed at one end. Just above the end closure and about 1/4" above the end is a 1/16" diameter hole bored through one side. The tube can have any convenient dimensions.

II. METHOD OF PROCEDURE

Manipulation: First cut the Gampi with the grain of the paper fibers into strips about 3/4" wide for regular fuse. For fuse of smaller diameter, cut strips so they are 1/2" wide or less! for larger fuse, cut the strips wider. Gampi tissue comes in sheets 18" x 20" The grain runs along the 20" way. The easiest way to cut it into strips is to start at one of the 18" sides and fold in half so a about 10" x 18" results. Fold in half the same way again. Fold in half the same way once more so a folded sheet about 2-1/2" x 18" results. Fold as carefully and press as flat as possible after each fold so all sides and corners are squared. Now with sharp scissors, cut the strips along the 2-1/2" direction to the desired width.

Dampen the board slightly with a sponge. Lay a strip of Gampi on the damp board and with the sponge, press it onto the board so it, too, is dampened and lays perfectly smooth and flat. With the powder applicator about half full, run it quickly over the damp Gampi so a thin and even stream of powder is applied down the center of the strip. Starting at the near left edge of the strip, the fingers of the left hand extended, the fingers push down and forward to start the Gampi rolling over itself. At the same time, the right hand fingers, also extended, are held against the near edge to act as a regulator to keep the Gampi from rolling over itself too rapidly, as shown in Figure 1.

The fuse is rolled starting at the tips of the left fingers and rolled in a continuous motion under the fingers until it comes almost to the base of the fingers as seen in Figure 2. Then this process is repeated, the right hand all the while acting as a regulator, until the dampened portion of the Gampi is rolled up. The rolling/twisting process is done at an angle with the fuse board, as shown in Figure 2.

When the fuse has all been rolled up, it is further twisted tight by laying it on a flat surface, placing both hands on top of it-the fingers extended, just like the position of the left hand during the rolling operation-then rolling and pressing forward with the left hand, and rolling and pressing in the opposite direction with the right hand, as shown in Figure 3. This operation is done all along the length of the fuse, starting at one end, and finishing at the other.

Fuse can be mass-produced by using a wider fuse board and dampening down several Gampi strips and pouring their powder trains first, then rolling them all up, one after the other. For fuse with heavier powder cores, cut the strips wider and use more powder. For larger diameters of fuse, roll the original fuse in more Gampi strips until the desired diameter is obtained.

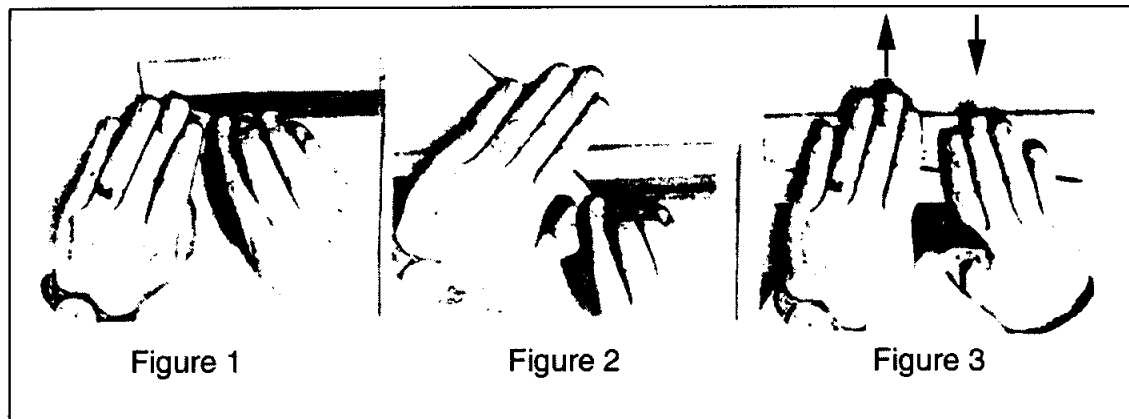
The fuse can be waterproofed by dipping it quickly into some liquid shellac, nitrocellulose based lacquer, or other waterproofing agent. The fuse must be made with enough paper to keep the agent from the powder core. This

(L-TR5)
"CHINESE" FUSE

is facilitated if tile agent evaporates very quickly. The waterproofing agent called "Visco", available from Westech is ideally suited, since it combines all the necessary qualities such as evaporation speed and water resistance.

Fuse can be made various colors either by using different colored Gampi, or by using a colored waterproofing agent.

Figures L-TR5-1, 2, 3 Chinese fuse rolling



TIME FUSE (L-TR5A)

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(L-TR5A)
TIME FUSE

I. INTRODUCTION

This time fuse has more of a peripheral powder train compared to the older time fuse with a central powder train. This gives this peripheral fuse much easier ignition properties because of the increased surface area of the powder train available to a flame. Thus, it gives more end spit than an equal weight of powder in a central core. It also gives a larger trajectory trace. To produce this superior time fuse perform the following procedure.

II. COMPONENTS/TOOLS

Paper: Ordinary writing or 30-pound Kraft paper.

Powder: The formula in Table L-TR5A is a good one for fuse powder.

Table L-TR5A-1 Fuse powder composition

Material	Parts by weight
Potassium Nitrate	6
Sulfur	1
Charcoal, dust	1
Dextrin	1/4
Aluminum, dust	ad lib

The Potassium Nitrate must be about as fine as powdered sugar. The "double refined powder" is best. The Charcoal must also be as fine as possible and be made from a soft wood such as willow. The "air-floated willow dust works best. Weigh accurately, and mix well (40 and 24 mesh mixing sieves are best). The resulting mixture can be used; however, a much more dependable fuse powder results if the mixture is placed in a ball mill (such as T-BMS or T-BML) and made into meal powder.

When the preceding formula burns, it leaves the usual gold trail of sparks. By adding some aluminum (bright pyro) to taste, the fuse will burn with a gold and silver tail, to one with a bright silver tail.

Tools: A board with a very smooth surface. Also required, is a "powder applicator" which is a metal tube, closed at one end. Just above the end closure and about 1/4" above the end is a 1/8" diameter hole bored through one side. The tube can have any convenient dimensions.

II. METHOD OF PROCEDURE

Manipulation: Since time fuse must be rolled to a diameter of 1/4" or larger, and since it is rolled from paper that does not have the wet adhesion qualities of Gampi tissue, it is easiest if the rolling is started around a hard "core" of some type. A core can be any hard object which the pyrotechnist finds easy for him to use. Examples of good cores are a length of "Chinese" fuse, and a bottle rocket stick. Use whatever is easiest for you.

Cut the paper into strips of the desired length and width. The dimensions depend upon how thick the time fuse is to be, what size is easiest for the pyrotechnist to use, type of paper, thickness of core, etc.

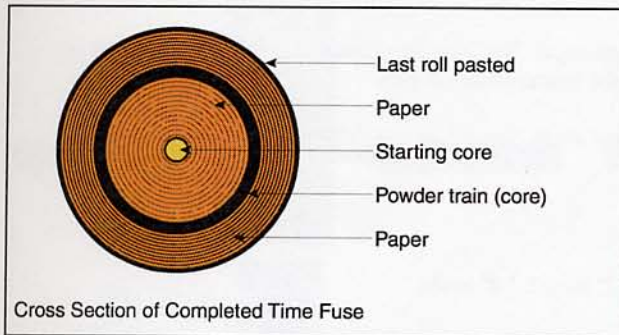
Dampen the board slightly with a sponge. Lay a strip of paper on the damp board and with a sponge press it onto the board so it too is dampened and lays perfectly smooth and flat. Place the core on the nearest edge of the paper and roll about 3 or 4 turns of paper around the core. Using the powder applicator, pour an even, flat train of powder along the paper, parallel to and for its entire length. The powder train width should be such so when it is rolled up in the fuse it makes one, complete turn or more. The thickness of the train depends upon the amount desired and the rolling skill of the pyrotechnist.

**(L-TR5A)
TIME FUSE**

After the powder core is rolled, continue rolling the paper until the desired diameter is obtained. At least 4 turns of paper should be rolled around the core of powder. Apply some thin paste to the last roll. Then, roll the completed fuse back and forth on the board, use as much pressure as it will take so it assumes a good tight construction. This last rolling operation is very important. Refer to figure L-TR5A-1

Make sure you use as much pressure as the paper will take during the whole rolling operation. The fuse must be rolled as tight and firm as possible, otherwise it will not burn evenly or could even explode like quickmatch. The addition of the dextrin to the powder helps give it a firmer construction.

Figure L-TR5A-1 Cross-sectional view of completed time fuse



MINI-COPTER (L-TR6)

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(L-TR6)
MINI-COPTER

I. INTRODUCTION

These are fireworks that begin to spin on the ground and then ascend rapidly in a spiral manner to a height of 100-125 feet, where they terminate with a loud report, or a shooting star.

Table L-TR6-1 Mini-copter composition

Composition	Parts by weight
Potassium Nitrate	18
Sulfur	3
Charcoal, dust.	4-6
Aluminum, dark pyro	1/2

The Potassium Nitrate must be about as fine as powdered sugar. The "double refined powder" variety is highly recommended. Mix thoroughly. A 24 mesh mixing sieve is the best and easiest way.

Casings: These are wet-rolled from any type of paper stock of 40 lb. (gauge) or less, 3/16" I.D. x 1-1/2" long x 1/32" wall. The casings, C-M (Westech) are ideal.

Ignition: Chinese type fuse, or 3/32" safety fuse.

Materials: Clay, glue, a piece of thin-gauge aluminum 2-1/2" long x 3/8" wide.

Tools: A rammer 2" long x 3/16" diameter. (Better tools consist of a funnel & rod).

II. MANIPULATION AND PROCEDURE

Place the casing on a firm surface and drive in some clay to form a plug about 3/16" thick. Punch a hole in the casing just barely above the clay and insert a length of fuse. Ram, in small portions, the composition until it comes to within 3/16" of the top of the casing. (An easier way to plug and fill the device is to use a funnel and rod, same as for filling bottle rockets.)

Now, lay the casing flat on the end of a table so the fuse is hanging freely over the edge and pointing downward at about a 45° angle with the table top. Using a razor blade, very carefully cut a slit halfway through the casing parallel to and just above the top of the composition. With a small dab of glue, secure the little aluminum wing in its exact center into this slit. The upper edge of the wing, located on the same side as the fuse, is now twisted back towards the fuse and the edge of the wing located on the opposite side is twisted forward as illustrated to provide the lifting effect.

A small charge of flash powder is poured in and a small plug of glue and clay (or tissue paper) is inserted into the top. The flash powder should not be packed. You may also place a small salute like an M-80 in the end of the casing. The M-80 should be end fused with a short length of visco or Chinese fuse.

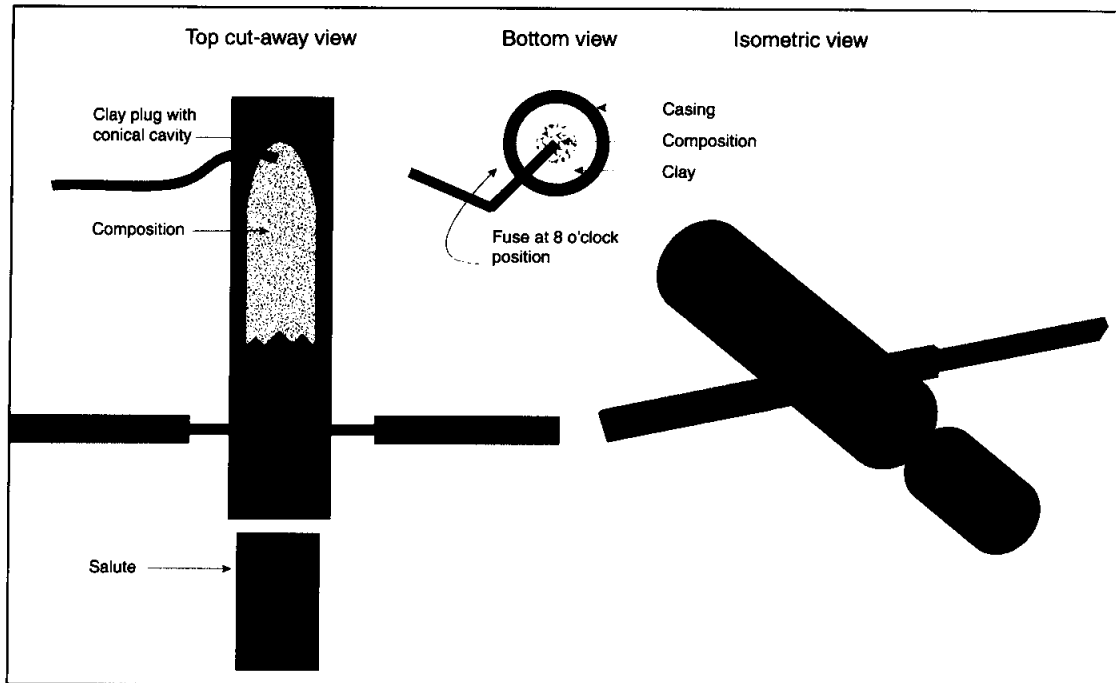
NOTE: The device will fly higher if after the fuse hole is punched, it is dipped into hot Sodium Silicate for about 15 seconds and allowed to dry. The Silicate should cover just above the fuse hole. It fire-proofs the hole so it doesn't increase in diameter from the hot gases.

III. OPERATION

To fire, the device is placed on a flat surface, wing side up as shown, so the fuse (which may have to be bent) is pointing at about a 45° angle downward. Refer to figure L-TR6-1.

(L-TR6)
MINI-COPTER

Figure L-TR6-1 Mini-copter illustrations



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ACCELOSEAL, Mass Production Method Of Plugging Tube Devices (L-TR7)

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**(L-TR7)
ACCELOSEAL**

I. INTRODUCTION

You'll find this method to be a very quick, easy, and inexpensive way of plugging one or both ends of any tube device (parallel or spiral) with a plug of any thickness in either end. This method uses a tool that can be easily constructed as follows.

II. CONSTRUCTION

Take a 1/4" thick piece of wood and drill as many holes through it as possible of the same diameter as the O.D. of the tubes to be plugged.

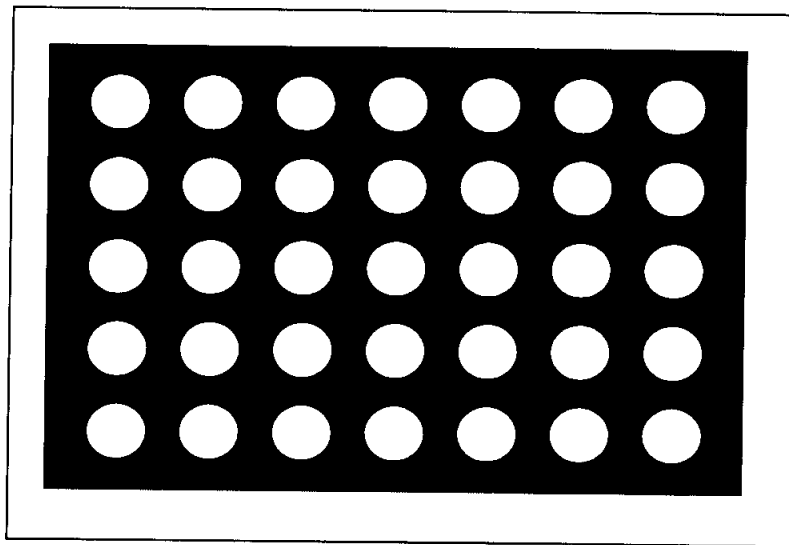
III. METHOD OF PROCEDURE

Take the board and lay it on a firm, flat surface. Sprinkle over the board some fine sawdust so each hole is partially filled with a thin layer about 1/16" to 1/8" high. Now push into the holes the tubes to be plugged. They should be pushed all the way through the holes and be seated well on the surface and sawdust below, so they are held firmly and upright by the board. The sawdust should protrude slightly into the tubes.

Pour into each tube the required amount of Professional Pyrotechnic Adhesive (or some other sealing material equally effective). The sawdust keeps the adhesive from sticking to the surface below. When the adhesive is dry, pour in the required amount of composition smoke, flash, etc. instead of waiting for the adhesive to dry, a thin layer of sawdust can be poured on top of it and then the composition added. Now pour in on top of the composition the necessary amount of sawdust to leave slightly less than the required space in the top of the tube. Pour in the required amount of adhesive which will slightly compress the sawdust and give a plug of the required thickness.

This method can also be use without the board for plugging small numbers of tubes. However, even small quantities are made easier if the board is used. Refer to figure L-TR7A-1.

Figure L-TR7A-1 Acceloseal tool illustration



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WHISTLING ROCKETS (L-TR8)

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(L-TR8)
WHISTLING ROCKETS

I. INTRODUCTION

Composition: The composition is Potassium Picrate, prepared as follows: In a non-metal container pour 1 quart boiling water; add 4 ounces Picric Acid and stir with a non-metal rod until dissolved. Now add 1 ounce Potassium Carbonate, a little at a time, stirring continuously. *Note:* The mixture will effervesce as the potassium carbonate reacts with the picric acid. Allow to stand for an hour then scoop out the residue onto some paper and let dry. Carefully crush to a fine powder using a wooden dowel or rolling pin. Picric Acid and its salts are poisonous and a powerful yellow dye use care. 100% Picrate whistle composition burns with a sooty, black smoke. A greyish-white smoke can be obtained by using a composition of 60% Picrate and 40% powdered Saltpeter. Store Picric Acid or Picrates in non-metal containers with non-metal, tight fitting lids.

Casings: These must be wet-rolled from a very smooth paper since the tone of the whistle is greatly influenced by the degree of smoothness of the paper. The Manila Board (S-MB) stocked by Westech is ideal, or the Roman Fuse Casings (C-RF) give excellent results. Casings should be 5/16" I.D. x 1/2" O.D. x 1-1/2" long (or longer if desired).

Ignition: Any type of fuse.

Materials: A stick for guiding the rocket, 3/16" x 11" long (S-311)

Tools: A rammer made of wood or plastic, 2-1/2" long x 5/16" diameter.

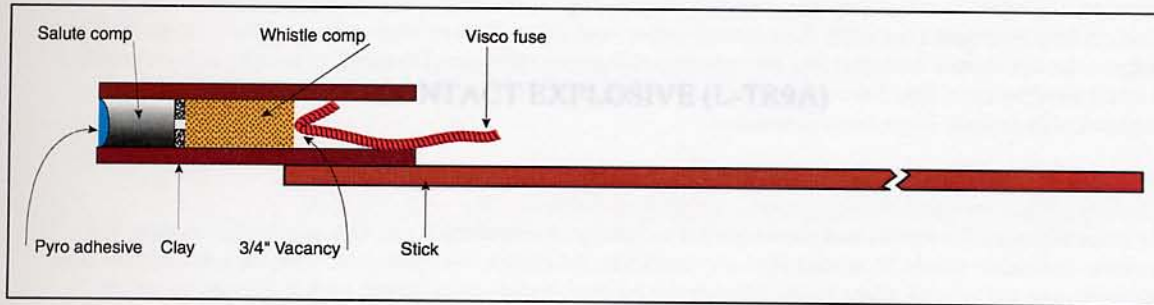
II. PRODUCTS OF MANUFACTURE

Manipulation & Procedure: The composition should be slightly damp when rammed or pressed into the casing. The correct amount of water to add to the composition is found by taking a pinch of composition and pressing between the thumb and index finger. If the composition feels damp, but no water runs out, then the composition is correctly dampened. Set the casing on a firm surface, put in a few pinches of composition and press firmly into place with the rammer using as much hand pressure as you can muster. Or, you can lightly tap the composition into place using sharp, light raps from a mallet on the rammer. Continue loading until the composition fills the case about half full. There should be about 3/4" vacant space for the proper production of sound. Allow to dry in a warm (not hot) place. When dry, attach the stick and match the vacant end. Rockets can be made to terminate with a sharp report by first ramming in a plug of clay using sharp blows from a mallet. Load the composition but do not dry yet. Then take a 1/8" diameter drill bit and bore a hole through the center of the clay plug by turning the bit with your fingers. When you hit the whistle composition, stop. Roll 4 or 5 turns of paper around the top of the rocket so about 1/2" extends beyond the end. Now dry. Add some salute composition, fold (or crimp) and tape (or glue) closed. *Note:* The salute composition should not contain any metals (aluminum, magnesium, etc.). Do not prime Picrate whistles; they will explode if they are primed.

CAUTION: Although this whistle composition is a fairly safe mix, only small quantities should be stored and handled at one time. When dry, Picric Acid and Potassium Picrate are sensitive to friction, shock, or heat. It should be remembered that Picric Acid is a close relative to TNT. (Picric Acid is tri-nitro-phenol; TNT is tri-nitro-toluene.) Picric Acid and Potassium Picrate are also very sensitive to metals and will form extremely sensitive high order primary explosives by merely coming in contact with metals. Therefore, no metals should be used around Picric Acid or its salts. However, contrary to Weingart and Davis, experience of many pyrotechnists has shown that Picrate whistles are safer to make than Gallic Acid whistles.

(L-TR8)
WHISTLING ROCKETS

Figure L-TR8-1 Whistling rocket cutaway view



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CONTACT EXPLOSIVE (L-TR9A)

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(L-TR9)
CONTACT EXPLOSIVE

I. INTRODUCTION

Nitrogen Tri-iodide is one of the most sensitive compounds known. Iodine and Ammonium Hydroxide in combination form Nitrogen Tri-iodide, Ammonium Iodide, and water. This substance does not burn progressively as black powder but instead detonates like nitroglycerin. When dry, Nitrogen Tri-iodide will explode from merely a breath of air blowing on it. Small dust size particles will pop and crackle when stepped on, when dry. A granule (1/8" square), will explode like a large firecracker.

II. METHOD OF PROCEDURE

To make Nitrogen Tri-iodide, two chemicals are necessary: Ammonium Hydroxide and iodine crystals. The Ammonium Hydroxide should be at least 30% concentration. Ammonia water with additives, such as the types used to wash walls, can not be used. Only Iodine crystals can be used. Solutions of iodine, such as tincture of iodine, used as an antiseptic, can not be used. Westech stocks the best grades of these chemicals for this use.

Place a small quantity of Iodine crystals (1-2 grams) in 1/2 cup Ammonium Hydroxide. Let stand for about 10 minutes, stirring occasionally. Now filter and wash with water. The residue is the explosive. If you do not have a funnel and filter paper, you can make one in the following way. Take a paper towel and fold it in half, then fold it in half from the other end. Put the point of the fold straight down into a small drinking glass and separate one of the folds of paper from the rest. When you pull this paper away from the rest you will have formed a cone. This is placed in the glass and the ammonia/iodine solution poured into it. The residue remaining on the cone is the explosive. Wash with water and keep WET until using.

Nitrogen Tri-iodide will not explode when wet but does so violently when dry. For storage, keep under water in an air-tight jar away from heat and light. Do not store longer than week or two, and store only small quantities (not more than a gram or two).

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JAPANESE AERIAL SHELLS (L-601A)

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JAPANESE AERIAL SHELLS: (L-601A)
BASIC CONSTRUCTION TECHNIQUES, PART 1: CASINGS

I. INTRODUCTION

When the Japanese desire a symmetrical burst pattern they use spherical casings. These consist of two parts: (1) an inner core composed of two hemispheres; and (2) an outside layer consisting of strips of posted paper. The outside layer is really one of the main secrets to the success of a Japanese pattern break shell. While the inner core merely serves as a container for the shell contents, the outside layer is extremely strong and thick, providing a tremendous resistance to the bursting charge and thus enables it to throw the stars to a great distance. However, if the layer is not evenly pasted all around, the shell will break unevenly and spoil the symmetric effect.

A. Inner Core

As was stated before, the inner core acts only as a container for the shell contents. They can be constructed by several methods. The Japanese make them by cutting circles of a soft, porous paper and then hydraulically pressing them with a die into a mold to form a hemisphere. They can also be made by hand using paper mache, or by following the methods described by Weingart. However, the best hand method is as follows.

II METHOD OF PROCEDURE

Cut some circles of 40 to 50 pound Kraft paper and some circles of "red rosin paper" (a variety of construction paper available at most lumber yards). The size of the circles depends upon the diameter desired of the aerial shell, as shown in table L-601A-1

Table L-601A-1 Shell Dimensioning Table

Shell Size Designation	Finished Core Size		Outside Layer Thickness	Actual Completed Shell Size	Approximate Diameter of Circles
I.D.	O.D.				
2	1-1/2	1-5/8	1/16	1-3/4	3-1/2
3	2-3/8	2-5/8	1/16	2-3/4	4-3/4
4	3-3/8	3-5/8	1/16	3-3/4	6-1/2
5	4-1/4	4-1/2	1/8	4-3/4	8-1/4
6	5-1/8	5-3/8	3/16	5-3/4	9
8	7	7-3/8	5/16	7-11/16	12
10	8-3/4	9-3/8	5/16	9-11/16	14-3/4
12	10-3/4	11-3/8	5/16	11-11/16	17-1/2

NOTE: The dimensions given for the cores are for Chrysanthemum/Peony (CP) type shells. C/P shells are those that burst with a very wide and rapid spread of garniture. In order to accomplish this type of burst, C/P shells have a thick outside layer which provides a tremendous resistance to the burst charge. Other types of shells such as Willow or Parachute Shells don't have a rapid and wide spread of garniture. Thus they use a thinner outside layer. In order that all shells have the same diameter, the outside layer of Willow type shells is made thinner by increasing the O.D. of the inner core by approximately 1/16" to 3/16" and decreasing the outside layer by the same amount. The two types of casings can be summarized as follows: (1) C/P Type: Thin inner core; thick outside layer; large break. (2) Willow Type: Thick inner core; thin outside layer; small break.

Paste twenty or more circles onto a board, one on top of another, with so much paste between them they become soft and pulpy rather than stick together. The two kinds of paper should be used and a separate stack of each kind prepared. This is to make it easier to see where one layer of paper begins and the other ends. Cover a ball with a layer of aluminum foil, press tightly and smooth over. The ball should have a diameter equal to the I.D. of the finished core.

Press one, of the pasted circles over the top half of the ball, as shown in Figure L-601A-1A Using the same color circle, cover the bottom half of the ball so this half covers the top half about 1 1/4" as Figure L-601A-1B shows.

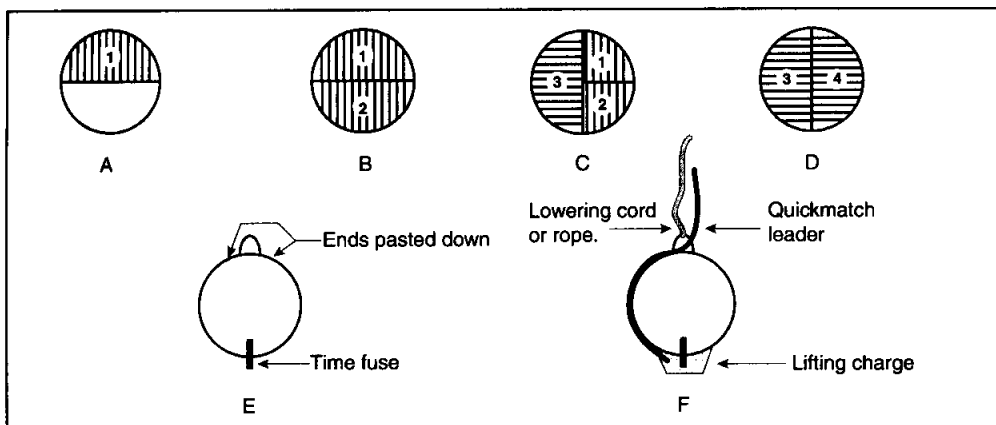
Now cover the left half with the opposite color circle and then the right half (with the same color circle used to cover the left half), as shown in Figures L-601A-1C and D. Repeat until the desired thickness is obtained. Let dry approximately two days, cut in half, mark halves so they can be fitted together smoothly.

Although ordinary wheat or wallpaper paste or any type of paper can be used, best results are obtained if the "embrittling paste" (formula and theory described in L-TR1) and the Kraft and Red Rosin papers are used.

Since making the cores is so time consuming, it is highly recommended that they be purchased ready-made. The "spherical shell casings" available from Westech Corporation make ideal cores since they are not only inexpensive but hydraulically pressed giving extremely uniform size and shape, something very difficult to obtain using hand methods.

JAPANESE AERIAL SHELLS: (L-601A)
BASIC CONSTRUCTION TECHNIQUES, PART 1: CASINGS

Figure L-601A-1: Shell wrapping diagram



B. Outside Layer

This is made by evenly pasting strips of 30-pound Kraft paper and strips of Red Rosin paper around the outside of the inner-core after the bursting charge and garniture are inside. The two hemispheres are joined together by first aligning the marks so the two halves are flush. Then they are joined together by pasting a 3/4" wide strip of 30-pound Kraft paper around the seam two or three times, each turn slightly overlapping the other. (Masking tape can also be used instead.)

Now comes the most important operation. The shell must now be papered with strips of Kraft and red rosin-type paper. The size of these strips depends upon the diameter of the shell. A good rule of thumb is to make their length about 1/2" longer than the diameter of the shell size designation and from 1" wide for 3" to 6" shells, to 2" wide for 8", 10" and 12" shells.

These strips are papered at right angles to the seam so the entire shell is evenly smoothly covered in the following manner. Cut the strips of paper and paste fifty, or more, onto a board, one on top of another, with so much paste between them that they become soft and pulpy rather than stick together. The two kinds of paper should be used and a separate stack of each kind prepared. The object of this is to make it easier for one to see where one layer of paper begins and the other ends.

Now take strips of paper from one pile first and lay them on the inner core, beginning at the top and running down to the bottom (fuse end). Lay the second strip so that it will lap over the first one about 1/4" at the bottom and almost over it on top, but 1/2" lower down. The third strip should start 1/2" still further down, while the fourth strip again starts at the top. This will prevent the case from becoming egg shaped as a result of having too much paper in one place. Continue this until the entire core has been covered. Each strip must be pressed down firmly and all surplus paste squeezed out with the fingers. Now repeat the operation using the other kind of paper. The strips should be worked so they lie as evenly and tightly as possible around the time fuse.

When the desired thickness has been achieved, a loop of strong twine is placed on the top of the shell (opposite from the fuse end) and the ends of it are covered with three or four small strips of pasted paper, as shown in Figure L-601A-1E. This loop serves to guide the leader from the lift charge (which will be situated under the time fuse) around the shell and eventually up and out the top of the mortar. It allows the shell to be lifted by the leader and placed in the mortar so the lift charge is exactly under the shell. Care must be taken so the shell is not situated in the mortar so the lift is off to the side somewhat. This will happen if the twine loop is not properly placed. A shell so situated may be shorn in two along the seam and "flowerpot" as it shears the inside of the mortar when fired,

A stout length of twine or rope should be attached to the loop on heavy shells to aid their placement in the mortar (see Figure L-601A-1F). This cord should be grasped and not the leader when the shells are lowered into the mortar. Heavy shells may damage the leader if it is used to lower them in place. Generally, this extra piece of cord should be used on all shells of 6" diameter and up.

JAPANESE AERIAL SHELLS: (L-601A)
BASIC CONSTRUCTION TECHNIQUES, PART 1: CASINGS

(NOTE: The preparation of the required strips of pasted paper and the operation of papering them to form the outside layer to the necessary thickness is very time-consuming and tedious. The above operation is the one used by the Orientals in constructing their shells. However, this whole operation can be greatly facilitated by using a special material available from Westech known as "Spherical Shell Wrapping." This material consists of cloth strips that give much more strength than paper and are already impregnated with an extremely strong adhesive. All that is necessary is to simply dampen these strips with water and apply to the shell. Since these strips are constructed of thick, webbed, cloth using a thick adhesive, less of these are required to make the outer layer, thus saving a tremendous amount of time, as well as making a stronger shell, and one that requires less time to dry.

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JAPANESE AERIAL SHELLS (L-601B)

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JAPANESE AERIAL SHELLS: (L-601B)
BASIC CONSTRUCTION TECHNIQUES, PART II: RICE-HULL POWDER

I. INTRODUCTION

Rice-hull powder is made by coating ordinary meal powder or a meal powder substitute on whole rice hulls. (Ground-up rice hulls will not work.) The resulting product is a porous mass of powder with a considerably lower density and greatly increased surface area than that of granulated powder. Because of this, rice-hull powder is actually more effective than an equal weight of granulated powder.

The coating of powder on rice hulls serves two purposes: (1) In order to be most effective the Japanese shells that break with a certain pattern must have the stars that form this pattern expelled with considerable speed in order to overcome the force of gravity and maintain their pattern. The increased effectiveness due to the physical state of rice-hull powder helps achieve this. Also important factors are the hard, outside layer of the casing and special black powder substitutes coated on the rice hulls instead of ordinary black powder. (2) Since the contents of most Japanese type shells are packed inside the shell extremely tight (in order to function properly), the rice hulls help maintain the porosity of the burst charge for a more effective break and use of powder.

II. PRODUCTS OF MANUFACTURE

The only way to coat the hulls is to pour them into a bowl of water. Allow them to become thoroughly saturated with water (takes about 30 minutes). Drain off the excess water, dump the soaked hulls into a box or bowl, pour in some dry meal powder over the bottom of the box or bowl so the bottom is lightly but completely covered. Then dump just enough of the soaked and drained hulls into the box so they form a single layer over the powder. Quickly sprinkle some more dry powder (about the same amount as used before) over the hulls and shake the whole lot until the powder is thinly but completely and evenly coated on each of the hulls. The hulls should be so covered with powder that they have a dull, black appearance. If they appear shiny they are too damp and/or not enough powder was used to cover them. They should not stick together too much either. Only practice will tell exactly how much powder to use so they are neither too thinly nor thickly covered or are too damp or dry.

NOTE: For some excellent meal powder substitutes all as effective or more effective as commercial black powder, see the formulas and processes listed in L-TR4

When the hulls are coated, spread them out evenly on a clean surface to dry.

CAUTION: When dry, rice-hull powder is HIGHLY FLAMMABLE.

JAPANESE AERIAL SHELLS (L-601C)

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JAPANESE AERIAL SHELLS: (L-601C)
BASIC CONSTRUCTION TECHNIQUES, PART III: ROUND STARS

I. INTRODUCTION

Stars used in Japanese-type shells are always spherical in shape. By contrast, domestic or European stars are cubical (cut stars), or cylindrical (pumped and box stars). Round stars are based on the simple principle of building-up successive layers around a central core. Although this may seem obvious, the exact way of doing this has long remained a mystery to Western fireworks makers. The secret is to add dry material to a damp core.

There are two types of round stars. Both types are made using the above principle. The first type uses a small seed, or other very small, round object as the core. The second type uses a small, cut star as the core. This type is usually used in the manufacture of color-changing stars.

II. PRODUCTS OF MANUFACTURE

Type I

The Japanese use small, round seeds, or other small objects such as buckshot to act as the core. The small (about 1/16" diam.) candies used as cake or cookie decorations work very well. Whatever core is used, pour a quantity of them into an ordinary mixing bowl, dampen them slightly with water sprayed from an atomizer. Now sprinkle some dry star composition over the dampened cores and rotate the bowl rapidly, so the cores swirl around, picking-up compo evenly on their surfaces. When it appears that all the compo has been picked up, dampen the now miniature stars as before, sprinkle on more compo, and rotate the bowl again. This process is continued until the stars are the desired size.

Try not to spray the sides of the bowl with water when dampening the cores, since they will adhere to anything wet. Try to keep the sides as dry as possible at all times. If the sides become too damp, the dry compo will build-up on them due to the rolling action of the cores, instead of on the cores themselves. The correct amount of dampening will come only with practice. The amount of dry compo to be added also can be ascertained by experience. Add enough each time so all of it is picked-up by the cores and none is left in the bowl. Of course, more will have to be added each successive time.

Type II.

The same process is followed, but instead of small, round cores, cut (or pumped) stars are used. The stars may either be used immediately after they are cut while they are still damp or they can already dry and then sprayed damp as explained above.

To make color changing stars, simply start with a cut star of one color, dampen, and use dry compo of another color. Or, just change compos once a layer of one color is sufficiently thick. The exact thickness must be found by experience, since it depends on the type of compo being used, size of star, placement in relation to the outside of the star, and other factors. Each color should burn long enough so a definite color can be observed and appreciated.

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CHRYSANthemum, PEONY SHELLS (L-602)

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JAPANESE AERIAL SHELLS: (L-602)
CHRYSANTHEMUM, PEONY SHELLS

I. INTRODUCTION

These are probably the best known of Japanese aerial shells. The primary characteristic of these shells is the almost perfectly round symmetry and great size of the burst. The almost mathematical precision of the pattern produced is in direct contrast to the rather random spray pattern produced by an ordinary Euro-American shell. The effect is, indeed, like a gigantic flower blooming in the sky.

The difference between chrysanthemum and peony shells is in the stars used. Their construction methods for both are the same. A peony shell, according to a Japanese definition, "is the blossom without fire trace; and the chrysanthemum is one with a fire trace. Thus, the difference is that the peony appears in full brilliance only at the full bloom, just at the stars reach their greatest spread; the chrysanthemum is just as brilliant from start to finish. This difference is achieved by using fierce burning star compositions for brilliant burns, and less fierce, for less brilliant burns. Since the effect of either a chrysanthemum or peony shell is so quick, the difference is difficult to notice.

II. PRODUCTS OF MANUFACTURE

Chrysanthemum, Peony (C/P) shell construction

A C/P shell is made in the following manner. Place a inner core hemisphere on a board that has a hole cut in it to receive part of the hemisphere. This stabilizes it and leaves both hands free. Pour into the core some round stars so they form a single layer on the bottom and part of the sides. Then stack stars up all around the sides until they come to the top (equator) of the hemisphere. The stars should fit as snugly against each other as possible. Now push into the hemisphere a circle of Gampi tissue paper so it forms a layer over the stars and then pack rice-hull powder into this cavity. The powder should be packed in quite firmly. A cross-section as the construction should now appears shown in Figure L602-A.

Repeat the same operation with the other hemisphere. Now take a circle of Gampi with a diameter equal to the I.D., of the core. Place this over one of the loaded cores so it holds in the powder and stars while the whole loaded core is turned and placed over the other core so they fit together in a flush fit. Paper with a thick outer layer, finish, and lift (described in L-601-A). A cross-section of the completed shell after papering but before lifting appears in Figure L602-B.

Double, triple (C/P) shell construction

A double or triple petal C/P is made by placing two or three layers of stars around the core. Double petal shells are usually 6" and larger; triple are 10" and larger. So that everything can fit inside the base smaller stars with the same amount of burst, or less burst with regular size stars are used, depending on the effect desired.

Diadem Chrysanthemum shells

A type of chrysanthemum shell known as a "Diadem Chrysanthemum" shell gives a very nice effect and is easily constructed. The effect is about midway between the effect of a regular C/P shell and a Willow shell. If normal size stars are used the effect is exactly like (and indeed its construction is exactly like) the spherical shells made in the U. S. some 35 years ago. If very large stars (3/4" or larger) are used, the shell is a true Diadem shell.

The stars and Japanese rice hull powder are thrown in randomly in each hemisphere, as much as each will hold, then the two are applied together and completed as before.

Table L602-1 Shell size to star diameter

Diameter of Shell	Star Diameter
2"	3/16-1/4"
3"	1/4-3/8"
4"	3/8"
5"	1/2"
6"	5/8"
8"	11/16"
10"	11/16-3/4"
12"	3/4"
18"	1"
24"	1-3/8"

JAPANESE AERIAL SHELLS: (L-602)
CHRYSANTHEMUM, PEONY SHELLS

Figure L602-A Shell charging diagram

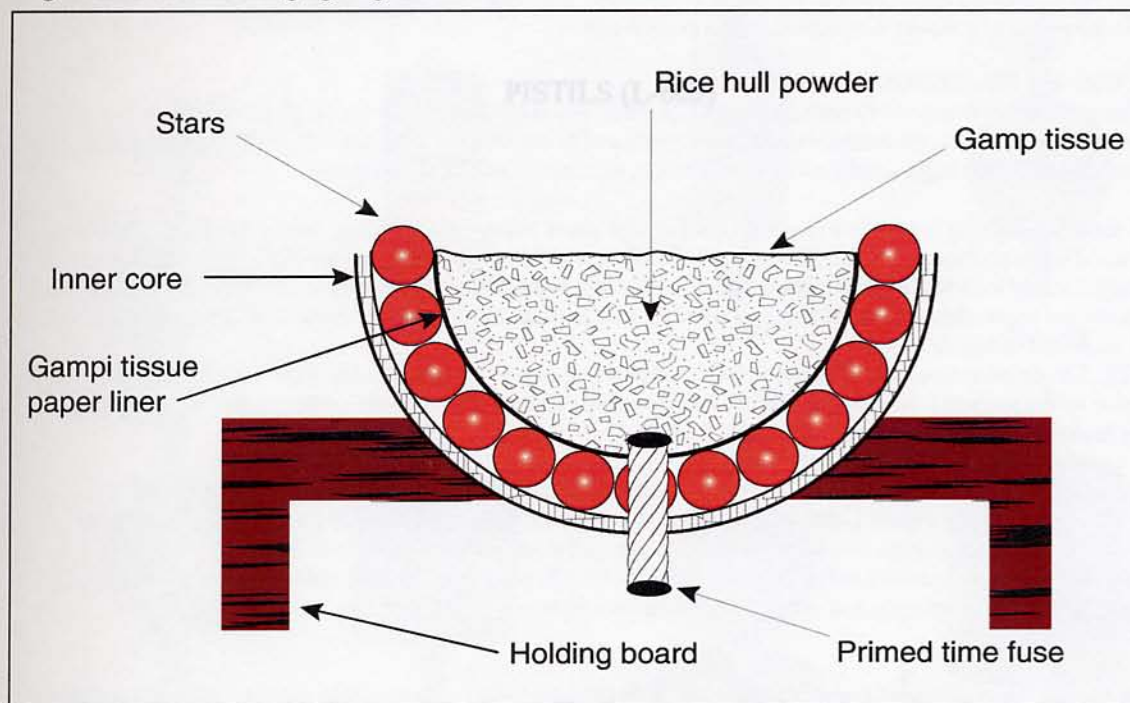
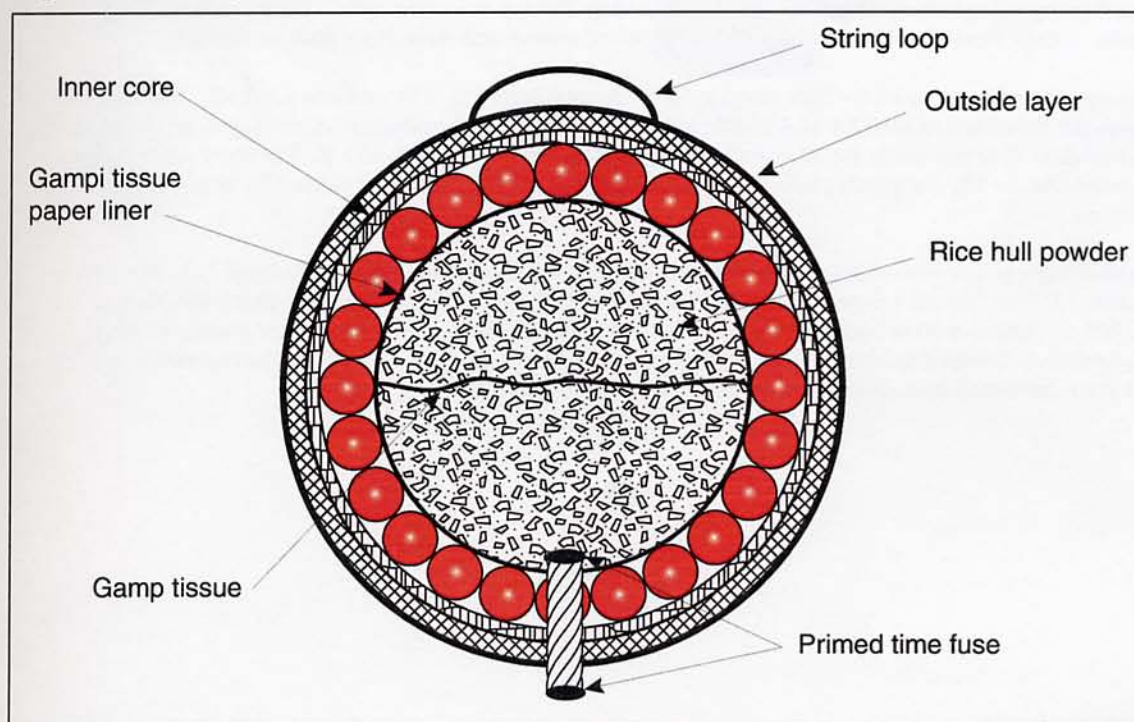


Figure L602-B Completed C/P shell



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PISTILS (L-603)

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JAPANESE AERIAL SHELLS: (L-603)
BASIC CONSTRUCTION TECHNIQUES: PISTILS

I. INTRODUCTION

Pistils are a small cluster of stars in the center of the larger star burst. The pistils form a sphere within a sphere, not unlike the pistils of a flower surrounded by the outside petals.

II. METHOD OF PROCEDURE

A chrysanthemum peony (C/P) with pistils shell is really two shells, one inside the other; the inside shell being the pistils, the outside shell, the petals. The shell is constructed in the following manner. (The dimensions given are for a 6" shell.) A 6" shell is the smallest size shell that can have pistils added conveniently.

The inner shell casing is merely a single layer of Gampi tissue paper wrapped diagonally around with thread. It is constructed around a "support tube" 5" long x 5/16" O.D. x 1/4" I.D. First, the support tube is cross-matched 2-1/2" from one end with two pieces of black match, each piece being 1" long. One end of the tube is closed with a wad of paste and paper, then two or three pieces of black match about 2-1/2" long are inserted in the open end of the tube, as shown in Figure L-603-1.

NOTE: The construction of the C/P pistil shell is depicted in two composite figures. Figure L-603-A shows the construction of the support tube assembly (STA) and inner burst charge. Figure L-603-B shows the remaining shell assembly incorporation the STA in the finished C/P shell.

Then a piece of Gampi tissue 5" wide x 9" long (trimmed size) is glued on one of the 5" ends and made into a cylinder, 5" high, shown in Figure L-603-2. One end of the cylinder is then tied securely around the support tube, 1-3/4" from the open end, and the overlapping tissue is trimmed close to the twine, seen in Figure L-603-3. The inner burst charge is now poured into the bag formed by the Gampi around the support tube. The bag is formed into a ball, and the top is then securely tied with twine and its ends trimmed closed to the tie, as shown in Figure L-603-4.

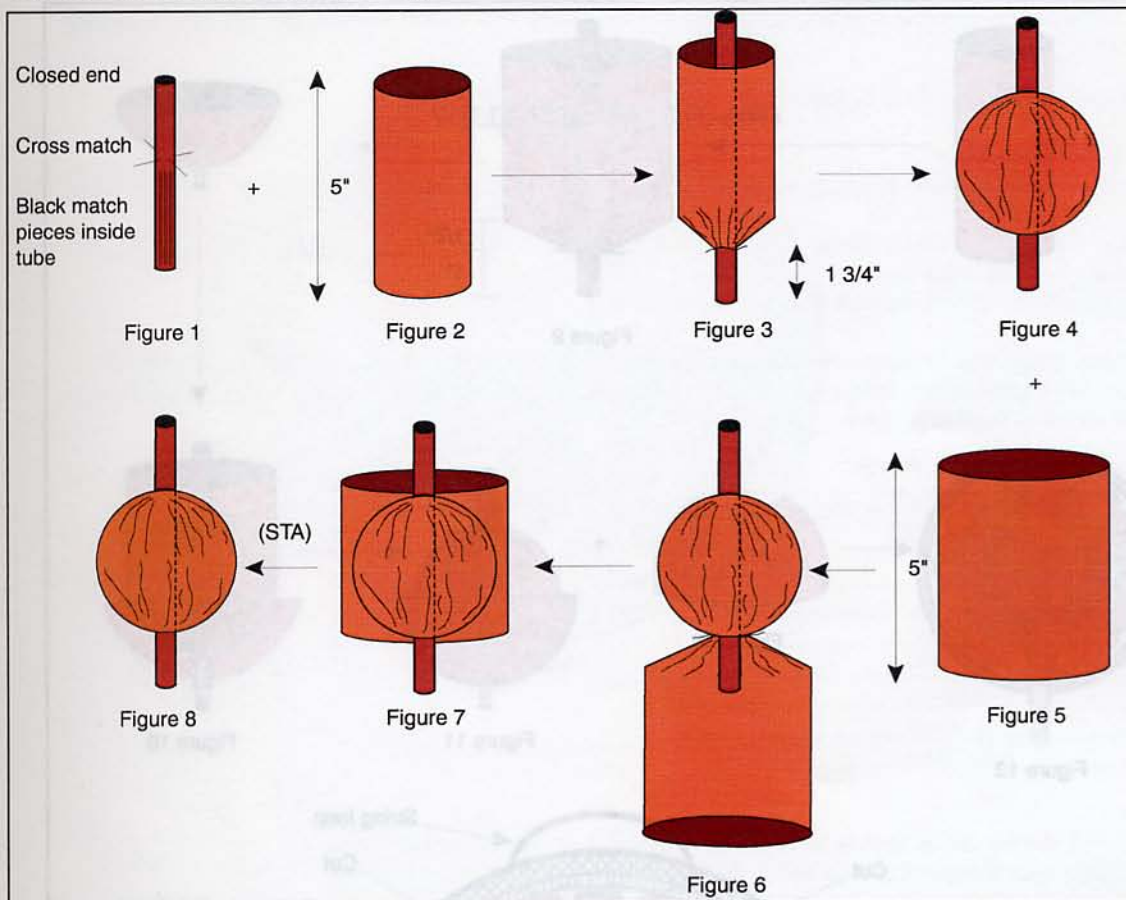
Now another piece of Gampi tissue 5" wide x 10" long (trimmed size) is formed into another cylinder 5" high, seen in Figure L-603-5. It is securely tied just below the ball of burst powder, as shown in Figure L-603-6. Then it is pulled over the ball, enclosing it inside as shown in Figure L-603-7. The inner stars (to form the pistils) are now poured in, forming a single layer all around the inner burst bag. The top end of the cylinder is securely tied to the support tube, seen in Figure L-603-8, and then it is wrapped all around with thread so it forms a firm ball.

A strong piece of paper towel (or light cloth) to form the outer burst bag is formed into a cylinder. One end is tied 1" from the closed end of the STA as shown in Figure L-603-9. This assembly is now glued over the time fuse (time fuse extends 1" or less inside the inner core hemisphere), as seen in Figure L-603-10. The outer burst charge is now poured into the bag and tightly packed in to form a ball and the loose ends tied to the STA and trimmed close to the tie.

A layer of stars is now poured in between the inner core hemisphere and the outer burst charge bag, shown in Figure L-603-11. Now, cut out a segment 2-3/4" in diameter out of the top of the other inner core hemisphere, Figure L-603-12. Secure this cut hemisphere to the other with two or three laps of masking tape around the seam. Now a layer of stars is forced in between the bag and the casing, shown in Figure L-603-13. The segment is glued back into place; then the whole shell is given a thick outer layer of papering.

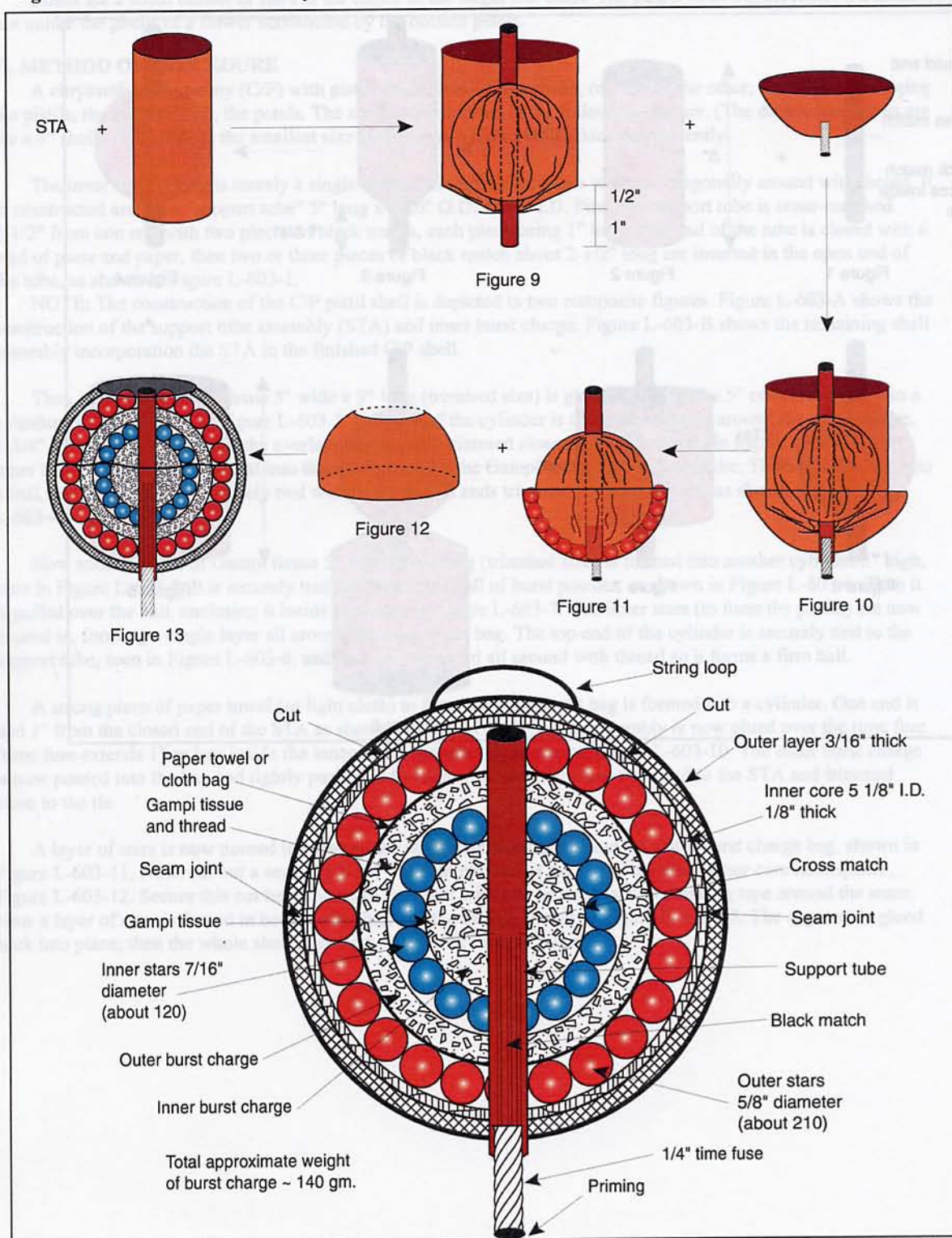
**JAPANESE AERIAL SHELLS: (L-603)
BASIC CONSTRUCTION TECHNIQUES: PISTILS**

Figure L-603-A Support tube assembly construction



**JAPANESE AERIAL SHELLS: (L-603)
BASIC CONSTRUCTION TECHNIQUES: PISTOLS**

Figure L-603-B C/P shell assembly



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WILLOW SHELLS (L-604)

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JAPANESE AERIAL SHELLS: (L-604)
WILLOW SHELLS

I. INTRODUCTION

A willow shell has a burst that resembles the shape of a willow tree. The burst is not anywhere as wide as the burst of a Chrysanthemum, Peony (C/P) shell, and the stars in the willow shell burn a much longer time than do those in the C/P shell.

II. METHOD OF MANUFACTURE

Willow shell construction

To achieve the hemispherical, drooping effect, the willow shell employs the following methods:

1. Use of a very light bursting charge
2. Use of a very thin outer layer
3. Filling only one-half of the shell with active components

The bursting charge is generally commercial black powder. Grain size is that of about FFg rifle powder. Black powder is used instead of rice-hull powder to give a bursting charge of less strength. The quantities to use in each size shell are given in table L-604-1.

Table L-604-1 Shell burst charge

Size of Shell	Quantity of Black Powder
2	2 grams
3	4 grams
4	6 grams
5	8 grams
6	11 grams
8	14 grams
10	21 grams
12	32 grams

NOTES:

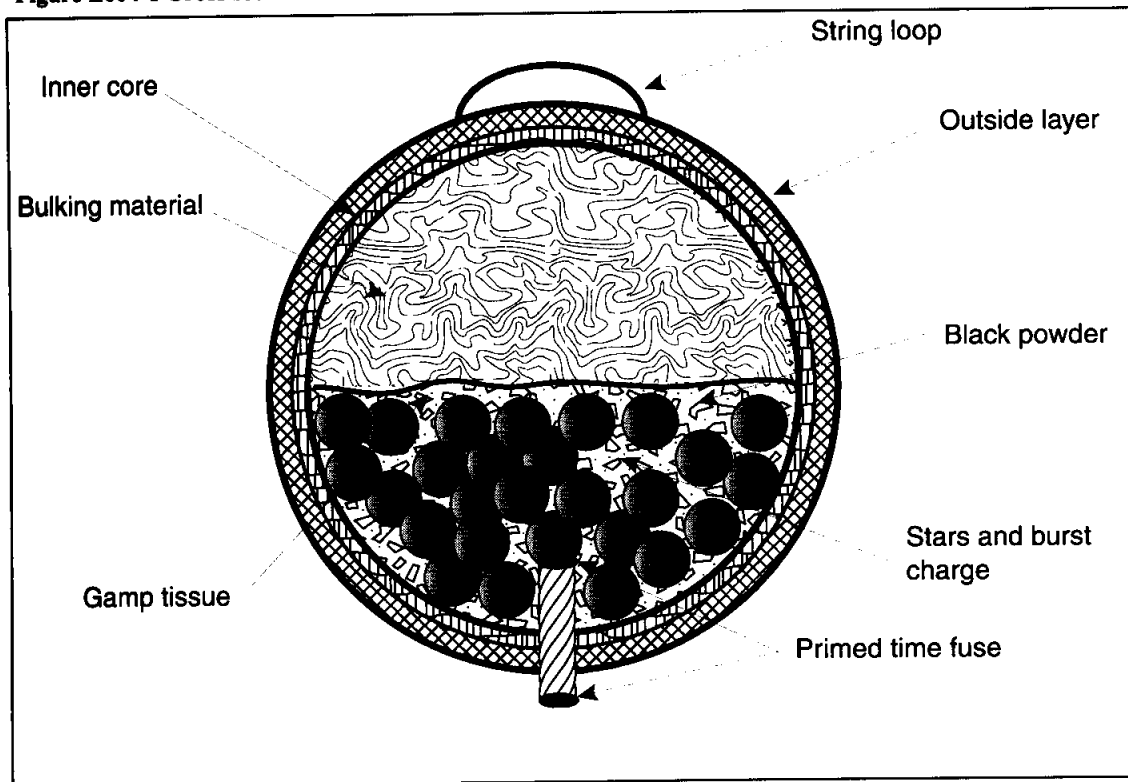
1. Rice-hull powder can be used in place of black powder, however less must be used.
2. The outer layer is papered at least half as thick as that of a C/P shell, (See L-601A).

The burst charge and stars or other garniture are contained in only the bottom hemisphere (the fuse half). The top half is filled with rice hulls, saw dust, or other bulking and held in position by a circular piece of paper pressed in over them. If the upper half was not filled with inert material, the shell would not burst with as much of a drooping effect, but more like a Diadem C/P shell. Also, with so little active material in such a large space with no bulking to hold it in a smaller space, the time fuse end spit may not fire the garniture if all of it had moved to the other areas of the casing.

Willows can be very effectively added to other shells that use a garniture that does not fill the entire casing. Examples are: Flag Shells, Figure Shells, Streamer Shells, Leaflet Shells, Dragon Shells, all types of Parachute Shells, Flower Shells, Criss Cross Star Shells, Falling Leaves Shells, Report Shells. Refer to figure L-604-1.

JAPANESE AERIAL SHELLS: (L-604)
WILLOW SHELLS

Figure L604-1 Cross section of a willow shell



The End